INTERAVIA

World Review of Aviation and Astronautics
With Electronics Supplement

Price of this issue—

U.S.A.:	$ 1.00
Canada:	$ 1.00
British Isles:	4/6
South Africa:	60 Cents (6s.)
Rhodesia:	6/6
Switzerland:	Fr. 3.50
Germany:	DM 3.50
Denmark:	Cr. 6.25
France:	N. F. 4.–
Italy:	Lire 500
Japan:	U.S.$ 1.00
Netherlands:	Fl. 2.80
Sweden:	Cr. 4.40

VOLUME XVI

In this issue

The New Jets Take Shape

Frankfurt/Main Airport • Aboard the Clemenceau

No. 2 / 1961

PHANTOM II The world's most advanced strike-fighter . . .

a weapon system with performance and versatility to insure air supremacy today —and tomorrow

In the Phantom II, McDonnell has refined and advanced the two-place, twin-engine concept to establish all-purpose strike-fighter utility.

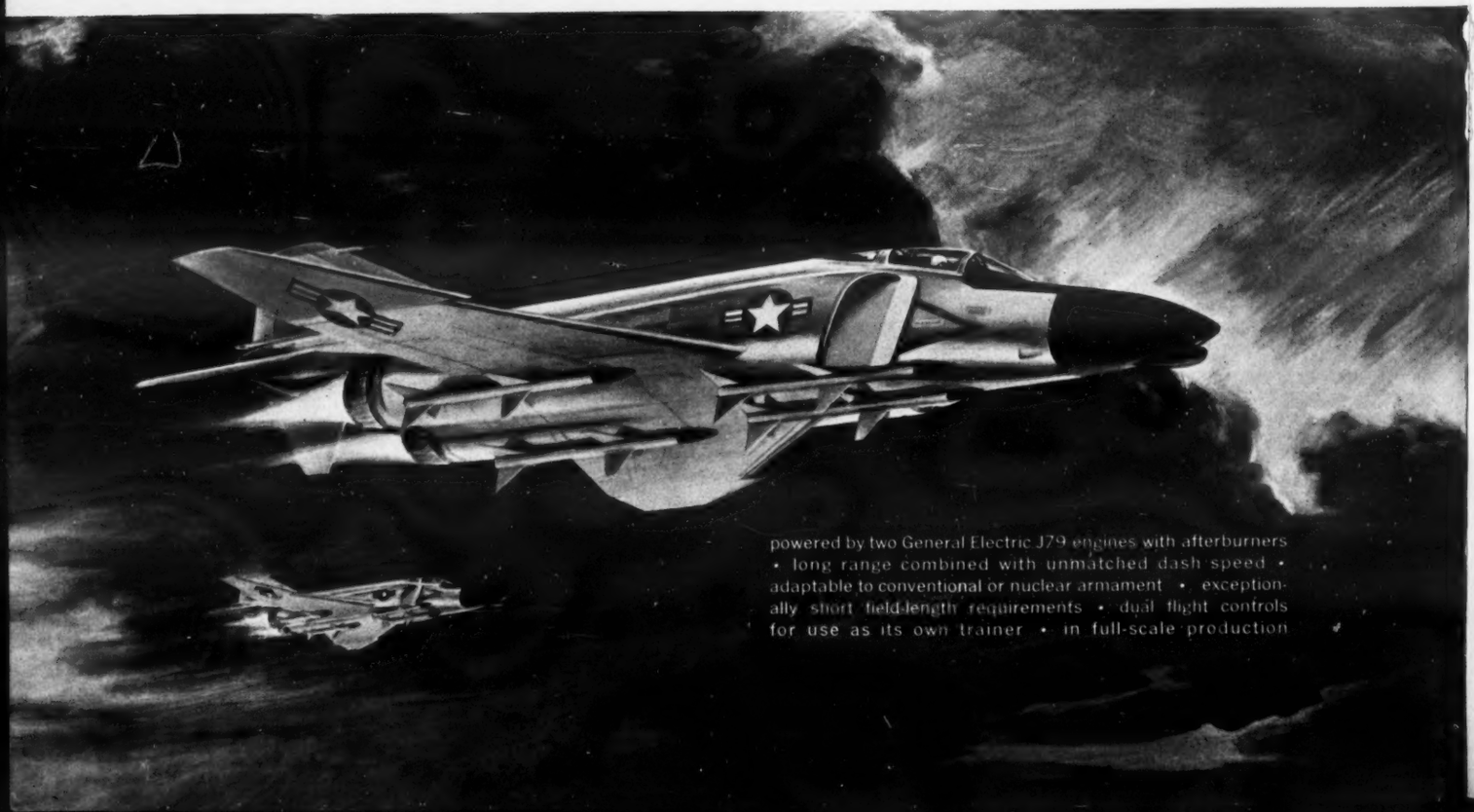
The Phantom II has attained a level-flight speed exceeding 1500 mph and has reached an altitude of 98,560 feet. It holds world closed-course speed records for 100 and 500 kilometers. Its numerous store stations can accommodate a variety of air-to-air missiles as well as virtually every ground attack weapon in the NATO arsenal. It combines excellent control characteristics throughout the flight envelope with the most advanced weapons-delivery techniques. Operating from either land bases or carriers, the Phantom II is designed to master any ground or air combat situation.

The Phantom II can replace three specialized aircraft. As an all-weather interceptor, as an air-superiority fighter, as a strike aircraft, the Phantom II achieves maximum defense through functional flexibility.

MCDONNELL

Phantom II and F-101 Voodoo Interceptor and Strike Aircraft • Project Mercury Spacecraft • Talos Airframes and Propulsion Systems • Quail Decoy Missiles • Rotorcraft • Electronics Systems • Automation

MCDONNELL AIRCRAFT ST. LOUIS, MISSOURI, U. S. A.



powered by two General Electric J79 engines with afterburners • long range combined with unmatched dash speed • adaptable to conventional or nuclear armament • exceptionally short field-length requirements • dual flight controls for use as its own trainer • in full-scale production

Volume XVI

INTERAVIA

February 1961

WORLD REVIEW OF AVIATION AND ASTRONAUTICS

Jet Transport

The New Jets and their Demands 163
The Decade Ahead 164
Jets of Tomorrow 167
The Convair 990 176
Boeing Experience with Jet Airliners 178
A Manufacturer's Assessment of Sales Prospects . . . . . E. F. BURTON 183
Atmospheric Phenomena Connected with the Jet Stream . . . . . W. PARTL 184
Long-Range Jet Aircraft Cruise Performance . . . . . J. F. RENAUDIE 188
The Answer to the Puzzling Riddle : "What Makes an Airline Profitable?" R. W. KLABZUBA 191
Production and Development of the Caravelle . . . . . L. GIUSTA 199
Some Thoughts on Future Civil Transports and their Safety Problems D. M. JAMESON 202

The Helicopter as a Weapons System F. L. VON DOBLHOFF 204
Frankfurt Airport a Centre of Jet Operations K. PROCHAZKA 215
Rockets, Missiles and Space Vehicles 221
The French Navy Re-equips 231
What's in the Air? 239
What's New in Electronics? 234
The Remote Transmission of Radar Information H. HART 236
Fifty Years of Vickers 145
Tug-of-War over Skybolt 146
" Interavia Air Letter " reports... 135

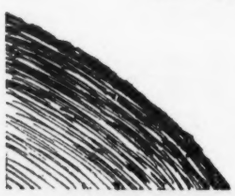
Front Cover : The first Convair 990 leaves the company's San Diego facility in California.

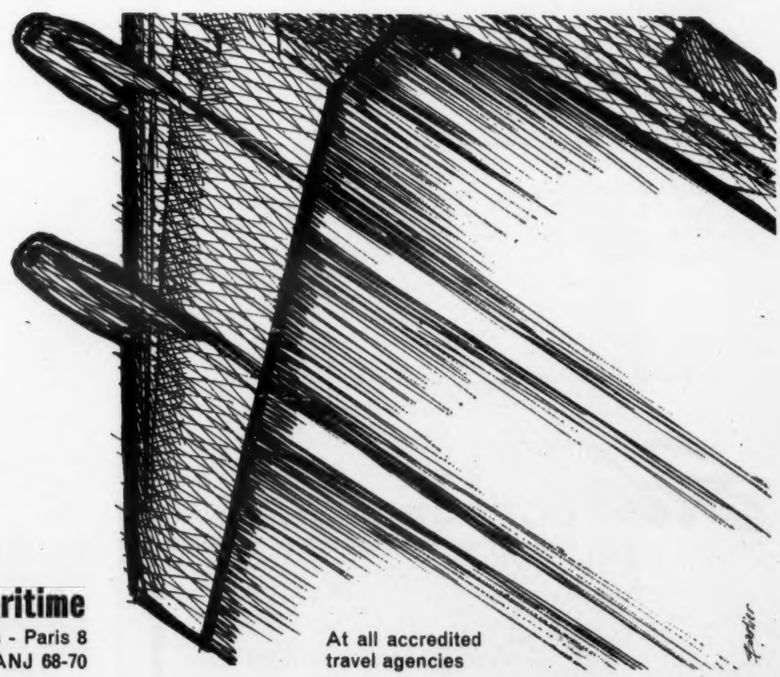
Now in service
on the network of

U★A★T

the DC-8
super jetliner

the most recent and the most advanced of the long-range jets will halve flight times to Africa





UAT aéromaritime
3 Bd Malesherbes - Paris 8
Tel. ANJ 78-04 to 09 and ANJ 68-70

At all accredited
travel agencies

WORLD LEADER IN LONG RANGE NAVIGATION

To date, these airlines
have installed Edo Model 345A Loran
as long-range navigation equipment:

- Aerolineas Argentinas
- Air France
- Alitalia Airlines
- BOAC
- Canadian Pacific Airlines
- Cubana Airlines
- Eastern Air Lines
- El Al Israel Airlines
- Flying Tiger Line
- Garuda Indonesian Airways
- Iberia Air Lines of Spain
- Irish Air Lines
- Japan Air Lines
- KLM Royal Dutch Airlines
- Lufthansa-German Airlines
- Northwest Orient Airlines
- Pan American World Airways
- Qantas Airways
- Sabena Belgian World Airlines
- Scandinavian Airlines System
- Seaboard and Western Airlines
- Swissair
- Trans Caribbean Airways
- TAI – Transports Aeriens Intercontinenteaux
- TWA – Trans World Airlines
- Varig Airlines
  - Also in use by MATS
    and growing numbers of corporate aircraft

For new illustrated brochure on Edo Loran write Dept. X-1.

Edo CORPORATION / Since 1925
College Point 56, L. I., N. Y.

In Canada:

Edo (CANADA) LTD.
Cornwall, Ontario

INTERAVIA

WORLD REVIEW OF AVIATION AND ASTRONAUTICS

Founder and Editor-in-Chief (1933-1959)
E. E. HEIMAN

Chairman and Managing Director
M. DEVAUD

Editorial Director
K. REGELIN

Technical Editors
E. BAUR, D. EBERT, K. PROCHAZKA

Associate Editors
E. K. BARNES, E. HERZFELD, A. ARBEX

Editorial Staff and Translators
J. S. COSANDEY, M. DESKAU, D. I. HOLMES, H. LAPIERRE, M. YESTE

Art Editors	Production	Circulation
H. W. MAHRER, A. HAAS	O. FISCHER	G. DENEKE

Business Managers
J. Vollenweider (Administration) — P. RUSSAK (Advertising)

Offices:

Paris: Georges FÉVRIER (Manager); *London:* Derek WOOD (London Editor); *Rome:* Giorgio LOURIER (Manager); *Bonn/Rhein:* Arno L. SCHMITZ; *Washington:* Harry TENNANT (Editorial Director U.S.A.).

Correspondents:

Amsterdam: Henk A. JANSEN; *Brussels:* Roger F. J. GILLYNS; *Athens:* Manos PAVLIDIS; *Bombay:* K. K. ANCHAN; *Johannesburg:* J. K. CHILWELL; *Linköping* (Sweden): Sven WALBERG; *Los Angeles:* Norman LYNN; *Madrid:* Luis SAENZ DE PAZOS; *Melbourne:* Kenneth GREEN; *Mexico City:* José VILLELA, Jr.; *Tokyo:* N. MATSUMURA; *Toronto:* M. WILLMOT; *Vienna* (and South East Europe): Max W. MORSTADT.

Agents:

Interavia Australasia 5, Tedstone Crescent, Balwyn E. 8., Victoria
Interavia Austria: Postfach 192, Vienna I./1
Interavia Belgium 149, avenue des Statuaires, Brussels 18
Interavia Canada 25, Farmcote Rd., Don Mills, Ont.
Interavia France 144, Avenue des Champs-Elysées, Paris 8me
Interavia Germany Schliessfach 99, Bonn 3
Interavia Great Britain 149, Fleet St., London, E.C. 4
Interavia Holland Henk A. Jansen, Olympiaplein 84, Amsterdam-Z
Interavia India No. 2 Grandhigram Rd., Juhu, Bombay 54
Interavia Italy 43, Via Latina, Rome 4.71
Interavia Japan Isogo P.O. Box 3, Yokohama
Interavia Mexico Apartado Postal 2297, Mexico 1, D.F.
Interavia Middle East P.O. Box 966, Graham Station, Beirut
Interavia South Africa P.O. Box 10242, Johannesburg
Interavia Spain Donoso Cortés 83, Madrid
Interavia Sweden P.O. Box 29, Linköping
Interavia U.S.A. 185, Madison Ave., New York 16, N.Y.
803, National Press Bldg.. Washington 4, D.C.
James C. Galloway, 6535 Wilshire Blvd., Los Angeles 48, Calif.

Distributors:

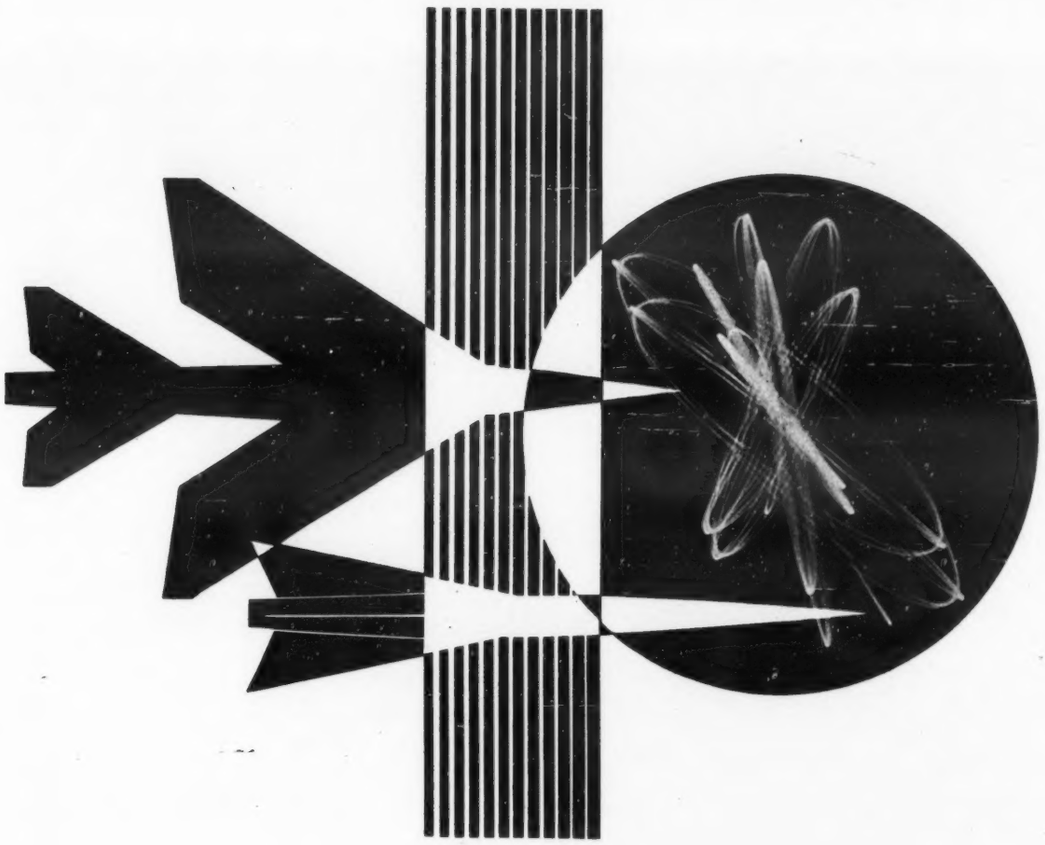
Argentine	York Agency, Tacuari 178, Buenos Aires
Austria	Morawa & Co., Wollzeile 11, Vienna I
Canada	Wm. Dawson Subscription Service Ltd., 587 Mount Pleasant Road, Toronto 12, Ont.
	Edward Company Regd., P.O. Box 98, Station Delorimier, Montreal P.Q.
	Gordon & Gotch (Canada) Ltd., 244 Bay Street, Toronto I.
Cuba	Tano Gómez, Prado 412, La Habana
Eire	Basil Clancy, Cooleevin, Foxrock Co., Dublin
Finland	Akateeminen Kirjakauppa, Keskuskatu 2, Helsinki
	Rautatiekirjakauppa Oy, Köjdenpunojank 2, Helsinki
Germany	W. E. Saarbach G.m.b.H., Gertrudenstrasse 30, Cologne
Great Britain	W. H. Smith & Son, Ltd., Strand House, Portugal Street, London, W.C. 2
	Wymans Ltd., New Street Square, London, E.C. 4
Japan	Maruzen Co. Ltd., 6 Tori-Nichome Nihonbashi, Tokyo
Norway	A/S Narvesens Litteraturtjeneste, Postboks 115, Oslo
Uruguay	Humanitas, Colonia 883, Montevideo
U.S.A.	Eastern News Distributors, Inc., 306 West 11th Street, New York 14, N.Y.
Venezuela	Michel Frochot, Apartado 2.648, Caracas

Advertising Department, Publishing and Editorial Offices, Subscription Departement: Interavia S.A., 6, Corraterie, Geneva. Telephone: 25 42 34 (five lines). Cables and Telegrams: Interavia-Geneva. Teleprinter: 22 122. Postal Cheque Account: Geneva I 5380.

Annual Subscriptions: U.S.A. and Canada, U.S. $9.00; United Kingdom and Eire, £2.12.6; Commonwealth, £2.12.6; Switzerland, 32.— fr.; Austria, 190.— sch.; Belgium, 370.— fr.; Denmark, 55.— kr.; France, 42.—N.F.; Germany, 32.—DM; Holland, 28.— fl.; Italy, 4735.— L. it.; Japan, U.S. $9.00; Latin American countries, U.S. $9.00; Norway, 57.— kr.; Spain, 450.— pts; South Africa, Rand 5.25; Sweden, 40.— kr. All othercountries, U.S. $9.00.
Second class postage paid at New York, N.Y.

Appears Monthly in Four Editions: English, French, Spanish and German

Copyright 1961 by Interavia S.A., Geneva, Switzerland

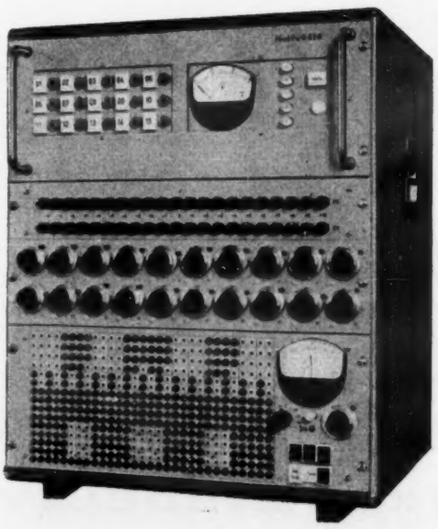


TRANSISTORIZED DESK ANALOGUE COMPUTER

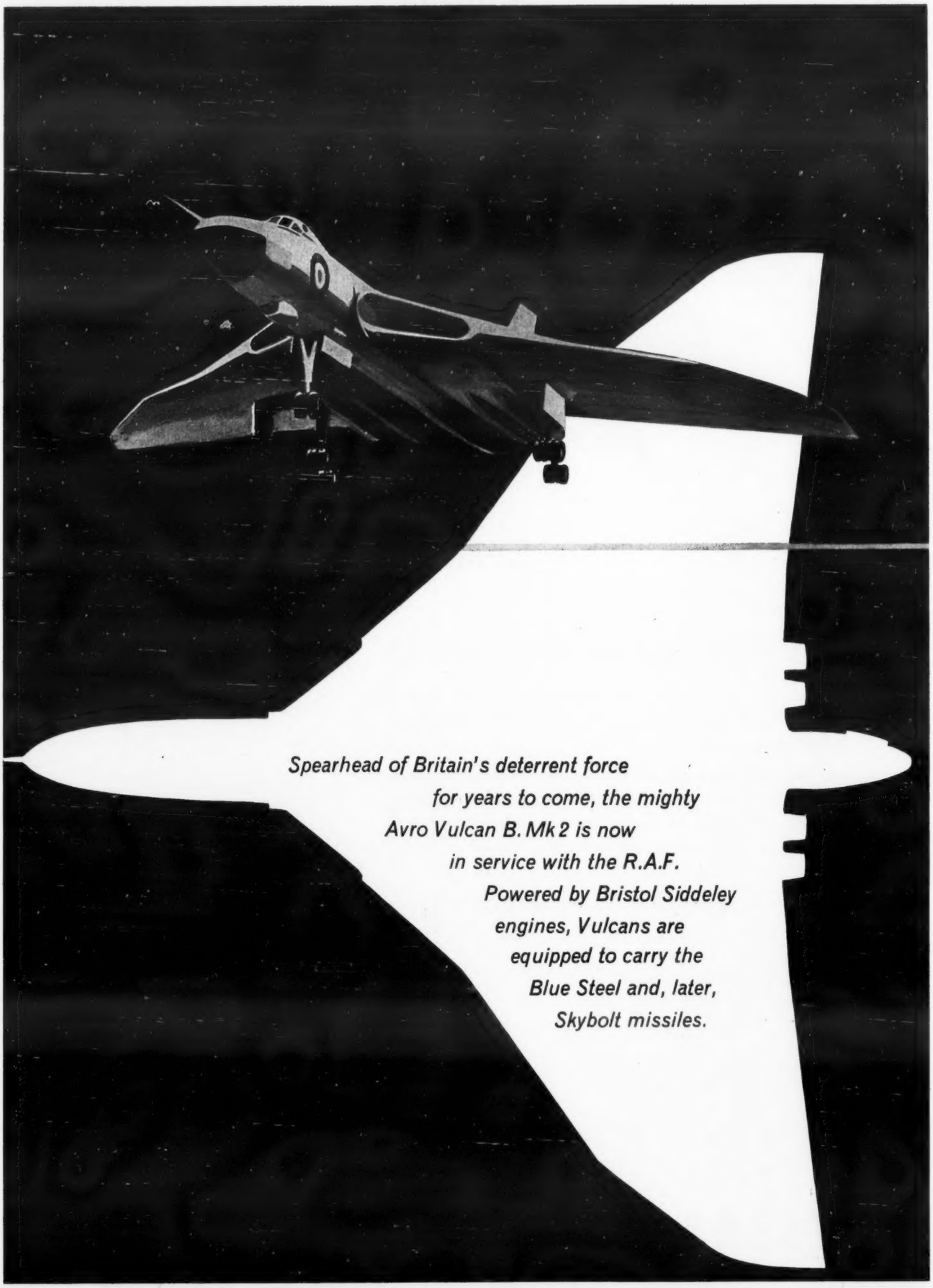
Stability, vibration, steering, control and navigation problems for flights at supersonic speeds and during landings can be reviewed and mastered with TELEFUNKEN analogue computers.

One Desk Analogue Computer RAT 700 can solve many problems and several computers can be connected in parallel to solve more complicated problems. Rapid, accurate and reliable, the Desk Analogue Computer RAT 700 is fully transistorized and transportable. Learning to operate it presents scarcely any difficulties.

The TELEFUNKEN Computer Centre in Konstanz will assist you in solving your problems.



TELEFUNKEN



Spearhead of Britain's deterrent force for years to come, the mighty Avro Vulcan B. Mk 2 is now in service with the R.A.F. Powered by Bristol Siddeley engines, Vulcans are equipped to carry the Blue Steel and, later, Skybolt missiles.

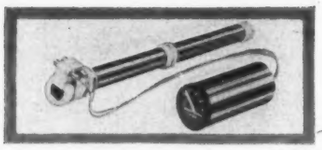
HAWKER SIDDELEY AVIATION *32, Duke Street, St. James's, London S.W.1*

STRÜVER Hydrant Dispensers for speedy refueling

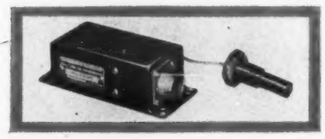
Strüver hydrant dispensers for aircraft refueling are fitted with short or long delivery hoses, depending on aircraft design and airline specifications. They are built in various sizes, both for overwing and underwing refueling, with the delivery system being adapted in every instance by our design engineers to individual requirements and to the truck chassis.

—We have just delivered 27 hydrant dispensers, for example, to Dansk BP, ESSO and SHELL for use at the recently enlarged Copenhagen—Kastrup airport, i.e. 10 units with a discharge rate of 600 I.G./min. and 17 dispensers rated at 350 I.G./min.

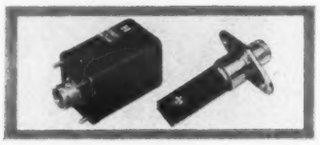
AD. STRÜVER KG TANKWAGENBAU HAMBURG



FQG

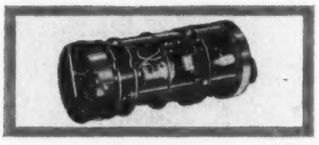


TLS

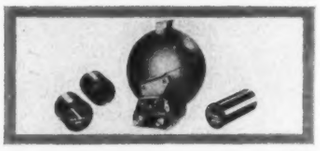


CLS

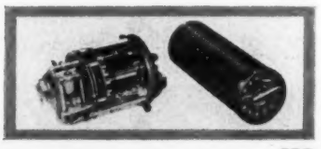
EGT



TEMP

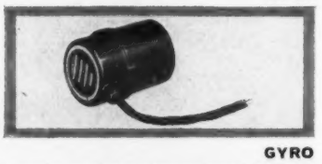


LOX

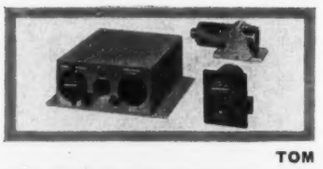


EPR

AFCS



GYRO



TOM

MSLS

HONEYWELL MEETS JET AGE WITH NEW TRANSISTOR INSTRUMENT LINE

FQG Fully transistorized Fuel Quantity Gaging Systems, light weight Tank Unit Probes for all applications. Characterized for linear dial presentations. Automatic Fuel cycling, refueling and center of gravity control.

TLS Light weight, reliable Thermister Level Sensing Systems for fuel sequencing and low fuel level warning.

CLS Capacitance Level Sensing System for automatic fuel control, oil level sensing and propellant loading. Applicable to most liquids and cryogenic fuels.

EGT Fully transistorized Exhaust Gas Temperature Indicating System. One half of one percent accuracy. Over-temperature warning, time/temperature recording and integrating.

TEMP Fully transistorized Temperature Indicating System for operation with standard AN resistance bulbs. Cabin air temperature, engine inlet temperature, cylinder head temperature, oil temperature.

LOX Fully transistorized Liquid Oxygen Indicating System and light weight characterized probes. Applicable to many cryogenic liquids.

EPR Engine Pressure Ratio for accurate jet engine thrust control and cruise control. Similar pressure devices for altitude and Mach control.

AFCS Honeywell offers a number of Automatic Flight Control Systems for multi-mode military applications plus less complex systems for other military and commercial uses. These systems include both linear and adaptive types for both aircraft and missiles.

GYRO Honeywell offers the world's most complete line of floated and non-floated gyros and accelerometers. Applications range from low cost air-to-air missiles, through aircraft controls, to the most precise space requirements.

TOM Automatic Take Off Monitor Systems to insure safe aircraft operation during critical take off phase of flight. Provides warning of deficient aircraft performance in time to insure a safe stop on the runway.

MSLS The Honeywell-Atkins Maximum Safety Light System insures greatest aircraft conspicuity during day and night flight operations. Provides information on direction, attitude and relative range.

Honeywell

Military Products

Sales and Service Offices:

HONEYWELL G.m.b.H., AUSTRIA
Vienna
Innsbruck

HONEYWELL S.A., BELGIUM
Brussels
Antwerp
Bruges
Charleroi
Ghent
Liege
Luxembourg

HONEYWELL A/S, DENMARK
Copenhagen
Aarhus

HONEYWELL S.A.R.L., FRANCE
Paris

HONEYWELL G.m.b.H., GERMANY
Frankfurt
Bad Godesberg
Berlin
Düsseldorf
Hamburg
Hanover
München
Stuttgart

HONEYWELL CONTROLS LTD., UNITED KINGDOM
London
Belfast
Birmingham
Cardiff
Dublin
Glasgow
Leeds
Manchester
Middlesbrough
Sheffield

HONEYWELL N.V., NETHERLANDS
Amsterdam
Hengelo
Rotterdam

HONEYWELL A.B., SWEDEN
Stockholm
Falun
Goteborg
Karlstad
Linkoping
Malmo
Skelleftea
Sundsvall

HONEYWELL A.G., SWITZERLAND
Zurich
Geneva
Basel

Grandissimo !

A REDIFON FLIGHT SIMULATOR

fitted with dynamic moving platform

WILL TRAIN

and check

ALITALIA CARAVELLE CREWS

Redifon Training Equipment serves the world's leading airlines—

AIR ALGERIE
AIR INDIA INTERNATIONAL
ALITALIA
BRITISH OVERSEAS AIRWAYS CORPORATION
CANADIAN PACIFIC AIRLINES
CENTRAL AFRICAN AIRWAYS
COMPANIA MEXICANA de AVIACION
DEUTSCHE LUFTHANSA
EL AL ISRAEL AIRLINES
INDIAN AIRLINES CORPORATION
J.A.T. YUGOSLAV AIRLINES
K.L.M. ROYAL DUTCH AIRLINES
PAKISTAN INTERNATIONAL AIRLINES
QANTAS EMPIRE AIRWAYS
SOUTH AFRICAN AIRWAYS
SCANDINAVIAN AIRLINES SYSTEM
SABENA
SWISSAIR
TRANS-CANADA AIRLINES
UNITED AIR LINES
UNITED ARAB AIRLINES
VARIG

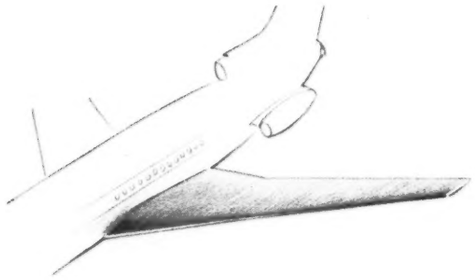
Redifon

REDIFON LIMITED FLIGHT SIMULATOR DIVISION, GATWICK ROAD, CRAWLEY, SUSSEX, ENGLAND

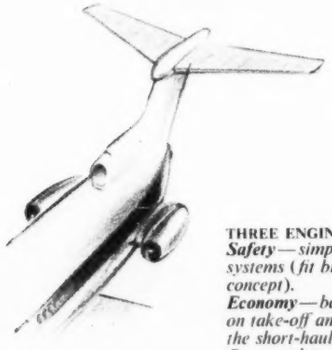
A Manufacturing Company in the Rediffusion Group.

EXPERIENCE

SHORT-HAUL JET—SHORT-HAUL RUNWAYS
6,000 ft. for maximum take-off weight and 5,800 ft. for average landings.



CLEAN WING
35° sweep—low drag with already nearly three years of aerodynamic testing: giving fast cruise for lowest cost. Simple wing structure, large-span uninterrupted flaps.



THREE ENGINES
***Safety**—simple triplexed systems (fit blind landing concept).*
***Economy**—balance of thrust on take-off and cruise for the short-haul duty. Reverse thrust simple. No ingestion problems.*

BLIND LANDING
FOR SAFETY AND YEAR-ROUND OPERATION IN ALL WEATHERS . . . *designed with fully automatic landing in view, and equipped from the outset for the first stage—auto-flare—at any airport having standard I.L.S. beam.*

explains the

DE HAVILLAND TRIDENT

The de Havilland Aircraft Company Limited — *Member Company of the Hawker Siddeley Group*

INTERAVIA AIR LETTER reports...*

Air Transportation

Ghana Airways has ordered three Vickers VC.10 jet transports, valued at £7 million. This is Vickers' first overseas order for the VC.10, of which BOAC has ordered 45. The Ghana Government has also signed a formal agreement for two Boeing 707 Intercontinentals for delivery in June 1962. The exact model (320 or 420, or perhaps 720B) is to be decided later.

●

United Arab Airlines-Misrair has ordered two more de Havilland *Comet 4Cs*. Misrair already has three *Comet 4Cs* in service.

●

British United Airways will spend £20 million ($56.4m.) on a new jet fleet if approval for a network of new routes to Europe and Africa is forthcoming from the Air Transport Licensing Board. BUA is prepared to buy up to four long-range Vickers VC.10s and five short/medium-range de Havilland DH.121 *Tridents* to operate the projected new services. ATLB hearings are scheduled to begin in mid-March. BEA will, and BOAC may, register objections.

●

South African Airways' damaged Boeing 707-344 (wheels-up landing Nairobi, October 30th) was repaired *in situ* and is now back in scheduled service. SAA's third 707-344 is due for delivery this month, already modified with full-length leading edge flaps.

●

Dr. Armand Robert (57), Senior Medical Officer with Air France and Chairman of the Airlines Medical Directors Association, died in Paris last month.

●

British European Airways' main helicopter interest is now centred on the twin-rotor turbine-powered Westland 194, currently under design and development at the Bristol division. BEA interest in the Fairey *Rotodyne* has all but disappeared, and it is unlikely to be developed for civil applications.

●

Alitalia is operating a new electronic computer centre (IBM 7070 and 1401 equipment) to handle spares inventory, sales and reservations, traffic statistics, and operational planning work at the Rome administration building.

●

Pakistan International Airlines will build a 300-room hotel in Karachi, in cooperation with PanAm subsidiary, Intercontinental Hotels Corp. Cost $7 million, for completion 1963. The two companies plan additional hotels in Rawalpindi, Lahore and other cities.

●

CAB decision on Philippine Airlines' application for a U.S.-Tokyo route is now expected mid-February.

Aeroflot inaugurated scheduled service Ilyushin Il-18 on the 3,600-mile route Moscow-Tiksi-Magadan (on the sea of Okhotsk) on January 12th. Tiksi, near the mouth of the Lena river, has over 20 flights a day to Moscow, Verkhoyansk and the North Siberian islands.

●

North Atlantic air passengers for the first time exceeded sea passengers by over 100 percent in 1960. Air passengers totalled 1,938,000 against 866,500 passengers travelling by sea. In 1956 1,008,000 passengers travelled by sea against 835,000 by air on the North Atlantic crossing.

●

IATA has announced the introduction of new economy class fares between points in Europe and South America, at rates considerably below those currently applying. Agreement was reached by Aerolíneas Argentinas, Air France, Alitalia, BOAC, Iberia, KLM, Lufthansa, Panair do Brasil, SAS, Swissair and TAP. The new rates are subject to approval by the governments concerned.

Industry

NASA's Flight Test Center has begun a research programme on a supersonic transport using a variable stability F-100C, an F-104 and the X-15 as test vehicles. Future plans for flight research investigation include the B-58 and the B-70 Air Force bombers, to provide information in direct support of design requirements for military and commercial supersonic transports.

●

First Vertol Chinook R & D models will be available within a few months, but the U.S. Army will not get production models for several years. The Vertol *Chinook* will be powered by twin T55 gas turbines and will have a 3-ton (32 combat troops) payload.

●

Joint French-U.S. satellite launch is planned for second-half 1962, probably using the U.S. *Scout* rocket, but with a French satellite. Pierre Piganiol, Delegate-General to France's National Committee for Scientific Research, will head a delegation to U.S. in March to complete negotiations. The U.S. has signed similar agreements with the U.K. and Canada.

●

Sud-Aviation has received Ministry of Aviation contracts for 17 *Alouette IIs* for the British Army. The Army already has two *Alouettes*, purchased for evaluation. *Alouette* sales now total 740.

●

Handley Page has offered Austrian charter operators Aerotransport and Austria Flugdienst two 44-seat *Dart Herald* turboprops on a lease-purchase agreement. The two carriers are in process of merging, and the new company is expected to take over major portions of domestic operation from Austrian Airlines.

Piasecki Aircraft Corp. has signed an agreement with the French Bertin company acquiring licence rights for Hurel and Bertin patents for VTO applications (jet-powered wing-mounted rotors).

●

Bristol Siddeley Engines has received a further order for *Orpheus 805* turbojet engines (4,000 lb thrust) from the Japanese Defense Agency. The original 1959 contract covered 32 *Orpheus* to power Fuji T1F-2 trainers for the Japanese Air Self Defense Force.

Max Hymans, President of Air France since 1948, has retired from active duty on health grounds, and has been appointed Honorary President of the national flag carrier. Hymans is succeeded by Joseph Roos (right), President of the Société des Usines Chausson, member of the Conseil Supérieur de l'Aviation Marchande and President of the Institut du Transport Aérien.

Vickers Super VC.10 may be dropped following BOAC studies showing unacceptable noise levels generated by four 24,000-25,000 thrust jets at full load take-off. BOAC may take an additional ten VC-10s (35 now on order) with increased seating capacity (190). Vickers is working on varied seating layouts, designated A, B, C and D versions.

●

Ferranti Airpass II may be bought for Australian and Swiss *Mirage IIIs* now on order. The company says that an Australian delegation will see the equipment in March, and the Swiss Air Force has asked for detailed specifications and proposals.

●

Meteor Company of Italy is building a C-version of its P.1 target drone at Monfalcone. P.1/C will have a 120 h.p. powerplant and a speed of 260 m.p.h.

●

SERIMA is a new joint French subsidiary established by SFERMA and International Aircraft Services Inc. SERIMA (Société d'Entretiens et de Réparations Industriels de Matériels Aéronautiques) will undertake NATO and USAF maintenance work.

●

Hollandse Signaalapparaten and Van der Heem N.V., will get important electronics contracts for European-manufactured Lockheed F-104Gs.

●

Mirage IIIC final assembly is being organized at Dassault's Bordeaux-Mérignac facility. Following completion of the pre-production series, first production models will be prepared for special operational testing by French Air Force. *Mirage* orders have been booked for Switzerland, Australia and Israel.

Aircraft

Boeing Airplane Company completed the first B-52H on January 5th. The aircraft's take-off weight is 490,000 lb; it is powered by eight Pratt & Whitney TF33-P-1 turbofan engines, each delivering 18,000 lb thrust. Range is

* Interavia Air Letter is a daily international news digest published in English, French ("Courrier Aérien") and German ("Luft-Post"). All rights reserved.

quoted as well over 10,000 miles. Externally, there is little difference between the B-52H and its predecessor, the B-52G. Since, however, it can be armed with an H-bomb and four Douglas *Skybolt* air-to-surface missiles with nuclear warheads, it has considerably improved striking power. The B-52 bomber has been in production for the USAF since 1956, and production of the B-52G was phased out last month.

●

The U.S. Air Force has taken delivery of the first of 35 Cessna U-3Bs which it has ordered. This is the military version of the Cessna 310F, an advanced version of the U-3A which has been in service with the USAF since 1957. With its two 260 h.p. Continental IO-470-Fs, the five-seat U-3B has a cruising speed of 220 m.p.h. U.S. Air Force units intend to use it for communications and light transport purposes. Spare parts will be supplied by Cessna's commercial dealer organization, so that the U.S. Air Force will not have to keep its own stock of spares for the aircraft.

●

The Morane-Saulnier MS.880 Rallye Club production prototype is nearing completion at the company's Puteaux plant, and tooling for series production is being prepared at Tarbes. This month the third prototype of this sports and touring aircraft (MS.885 *Super Rallye* with 145 h.p. Continental engine) will be rolled out, together with the fourth, which is designed for static load tests. In April, production will begin with four aircraft; sixteen will be delivered in May, twenty in June and thirty each month from July onwards.

●

Dornier-Werke GmbH offers the A-1(R) version of the Do 28A-1 as a work aircraft. An additional fuel tank has been provided in the fuselage, together with a revolving seat and a working table. The A-1(R) can carry 1,241 lb of fuel in its two fuselage tanks. Maximum take-off weight is 5,940 lb, maximum landing weight 5,500 lb. Maximum speed is 160 knots, against 177 knots for the 28A-1.

●

In the development of the Weser/Sikorsky W/S-64 flying crane, use is to be made of a large number of proven components already in quantity production. Externally, the W/S-64 is said to be similar to the S-60, the main difference being in the use of two Pratt & Whitney JFTD-12A-1 free turbines, with an initial take-off rating of 4,110 h.p. each (later to be increased to 4,680 h.p.). The power considered necessary for normal operation is lower than this. The surplus power will not only ensure good flight performance at high altitudes and in hot weather, but will also enable the helicopter to fly on one engine with full take-off weight. Technical data are as follows: rotor diameter 72.0 ft; overall length 87.4 ft; overall height 24.3 ft; track width 19.7 ft; fuselage height above ground approximately 10 ft; suspendable load 8 tons; useful load 53 percent of take-off weight. The configuration chosen for fuselage and undercarriage should enable the helicopter to land with nearly all kinds of loads, thus avoiding uneconomic hovering flight. Experience with the S-60 has shown that 80 percent of all loads can be taken on board on the ground. It should be possible to achieve an even higher percentage with the W/S-64, which has no tailwheel to hinder loading operations.

●

The Doman-Ambrosini D-10 six- to eight-seat helicopter is built under licence by Aeronautica Sicula, of Palermo. Most recent technical data are as follows: Lycoming ISO-720-A1A engine with 400 h.p. take-off rating and 350 h.p. continuous rating; operating empty weight 3,430 lb; gross weight 5,500 lb. Performance figures (for 5,200 lb all-up weight): service ceiling 22,100 ft; hovering ceiling 13,500 ft within the ground effect; maximum sea level cruising speed 85 knots; range with normal fuel supply 285 n.m. With an all-up weight of 5,500 lb, the service ceiling is 21,000 ft; hovering ceiling 5,500 ft within the ground effect; maximum sea level cruising speed 83 knots.

●

Metallwerke Friedrichshafen GmbH has received certification from the West German Federal Aviation Bureau for its PL 4360A non-rigid airship. This is a hydrogen-filled airship with ballonets at the nose and tail. It is powered by two Warner *Super Scarab* 185 AL piston engines (200 h.p. take-off rating at 2,475 r.p.m. and 185 h.p. continuous rating at 2,420 r.p.m.) with Hartzell variable-pitch propellers. Dimensions: length 157.6 ft; diameter 42.7 ft; overall height 92.7 ft; overall width 52.5 ft; volume (inflated to maximum) 159,000 cu.ft. Weight 10,230 lb. Maximum speed 56 m.p.h. The airship can carry up to six people.

A Sud-Aviation Caravelle VII, powered by General Electric CJ-805-23C turbofan engines (16,000 lb thrust each), began flight testing in the USA early this year. This aircraft, a cross between the Caravelle III *and* VI, *is still in the prototype stage; the production version has still to be built, assuming that sufficient sales possibilities exist. Fuselage nose will be lengthened by 40 inches. Cabin layout for 89 economy or 68 first class passengers.*

Space Research

Discoverer 17 was launched from Vandenberg AFB on November 12th, 1960, the instrument capsule being recovered in the air two days later. Early in January the *Agena B* booster stage entered the atmosphere and burnt up.

On December 7th, 1960 the U.S. Air Force put the *Discoverer 18* research satellite into an orbit with a perigee of 154 miles and an apogee of 459 miles; the angle of trajectory was 80.9°, the orbital period 94.1 minutes. The booster was a *Thor-Agena B*, the *Thor* first-stage motor having a thrust of 165,000 lb, an increase of 15,000 lb on the earlier thrust. In addition to instrumentation, the capsule contained tissue from a human eyelid, human bone marrow, algae, spores, gamma globulin, albumin, gold foil and various kinds of film. On December 10th the capsule was ejected after the 48th orbit and caught in the air by a Fairchild C-119 near Hawaii; the satellite had covered a distance of about 1,250,000 miles. This was the fourth recovery of a *Discoverer* instrument capsule, and the third recovery from the air.

On December 20th, the USAF launched *Discoverer 19*. The satellite had an orbit with a perigee of 120 miles and an apogee of 390 miles; its orbital period was 93 minutes. Unlike the previous satellites of the series, *Discoverer 19* had no ejectable instrument capsule, but carried infra-red measuring equipment and other unspecified electronic instrumentation. The final stage, with payload, weighed 2,100 lb. The satellite reentered the earth's atmosphere on January 22nd and burnt up.

●

Under Project Anna (Army-NASA-Navy-Air Force), satellites are to be used to measure long distances on earth with an accuracy of a few yards. Such information is particularly important for guided missile operation. NASA had originally planned to launch satellites for geodetic measurements, but in the new Project *Anna*, which is financed by the three armed services, its role is more or less that of an observer. It is probable that the instrument payloads will be put into orbit by *Scout*, possibly the U.S. Air Force *Blue Scout II*. The instrumentation may even be carried by *Transit* and *Discoverer* satellites.

●

The Sea Scout is proposed by the U.S. Navy as booster for a number of planned satellites. This is a four-stage solid-propellant vehicle consisting of the two stages of the *Polaris* and the two upper stages of the USAF's *Blue Scout* booster. The *Sea Scout*, which can be launched from ships, is designed to put 150 lb satellites into orbits about 350 miles high.

The editors have to apologize for an error in footnote (1) on page 91 of the English-language edition of *Interavia* Review No. 1/1961, in which the author was quoted as Professor Giovanni Gabrielli. The correct name is Professor Giuseppe Gabrielli.

Photo credits: Front cover: manufacturers; p. 145: manufacturers (2); p. 146: manufacturers (1); pp. 164-166: author (2), manufacturers (2); pp. 167-175: manufacturers (22), Interavia drawings (9); pp. 176-177: manufacturers (5); p. 178: manufacturers (1); p. 183: author (1); pp. 184-187: author (11); pp. 188-190: author (12); pp. 191-194: author (4); pp. 199-201: manufacturers (6); pp. 202-203: manufacturers (2); pp. 204-206: manufacturers (6); pp. 215-220: Frankfurt/Main Airport (6), Deutsche Lufthansa (5), Bundesanstalt für Flugsicherung (4), Telefunken (3), H. Hauser (1), Interavia drawing (1), Interavia files (2); pp. 221-222: U.S. Army (3), manufacturers (3); pp. 231-233: Interavia files (10); pp. 234-235: manufacturers (8); pp. 236-238: manufacturers (5); pp. 239-241: manufacturers (4), U.S. Navy (2), H. Levy (1), Havard (1), Schmidt (2), Interavia files (1).

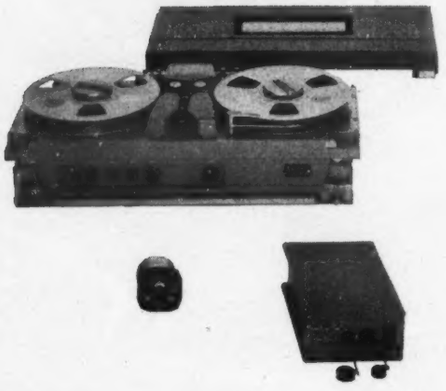
ALVIS Salamander

CROSS COUNTRY CHASSIS

The Alvis Salamander chassis is designed for unrestricted use in all types of terrain. It is a development of the highly successful Saracen and Saladin fighting vehicles. The Salamander is the basis of the world's most successful fire crash tender – using either Pyrene or Foamite fire fighting equipment – and is the standard aerodrome fire fighting vehicle for the Royal Air Force, Royal Canadian Air Force, Royal Ceylon Air Force and South African Air Force.

ALVIS

ALVIS LIMITED COVENTRY ENGLAND



The AMPEX AR-200

is an analogue magnetic tape recorder for airborne or mobile use. A completely integrated system, it occupies just 1.6 cubic feet of space and weighs only 95 pounds. The AR-200 performs reliably from −54° C. to +71° C., at altitudes to 100,000 feet, and will withstand 15g shocks and 10g vibration. Electronics are all solid state, and the recorder operates on 28 volts DC. Converters are available for use with other power sources. Standard speeds are 1⅞, 3¾, 7½, 15, 30 and 60 inches per second. The AR-200 can be used for direct, FM-carrier, PDM or digital recording. Models are available for up to 14 analogue tracks or 16 digital tracks I. R. I. G. compatible at no extra cost. For specifications write to Ampex Great Britain Limited, Arkwright Road, Reading, Berks., England. AMPEX

INTERAVIA AIR LETTER reports...

(contd. from page 136)

Powerplants

The Bristol Olympus 21 turbojet engine (20,000 lb thrust) is to go into production under the RAF designation *Olympus Mk.301*. The first *Olympus* had a maximum thrust of 9,000 lb and ran for the first time in May, 1950. From this was developed the "100 Series" production engine—starting with the Mk.101 of 11,000 lb thrust, and later the Mk.104 with a rating of 13,500 lb. In January, 1957 the *Olympus BOl.6* was type-tested at 16,000 lb thrust. This version went into production as the Mk.200 but was soon succeeded by the Mk.201 of 17,000 lb thrust. An advanced version of the *Olympus* has been specified for the British Aircraft Corporation TSR-2 supersonic strike/reconnaissance aircraft, and a version with reheat developing up to 33,000 lb thrust has been mentioned.

●

United Technology Corporation of Sunnyvale, Calif., has carried out the first static test firings of a new segmented solid-propellant rocket motor, to indicate the possibility of using segmented rocket motors as building blocks in very large boosters. The motor tested by UTC was a three-segment unit approximately 3.5 ft in diameter and 7 ft long; a thrust of 15,000 lb was measured. The propellant was developed at UTC, which built the motor in cooperation with Pratt & Whitney.

●

Stark Flugzeugbau KG, of Minden, Westphalia, has received type certification for its *Stamo 1400* flat four air-cooled engine (1400A version without starter, 1400B with electrical starter). Data are as follows: bore 80 mm, stroke 74 mm, capacity 1.488 litres, compression ratio 7.2. Dry weight with accessories (1400A) 121.2 lb, and (1400B) 129.56 lb. Take-off rating is 45 h.p. at 3,200 r.p.m. and a fuel consumption of 0.551 lb/h.p./h; economical power is given as 38 h.p. at 3,000 r.p.m. and 0.464 lb/h.p./h. As a Pallas Zenith NDIX 32/St 1 lubricant system and carburettor are used, inverted flight is not permissible.

Equipment

Etudes et Fabrications Aéronautiques (EFA), of Paris, has been given a contract for the development and manufacture of pressure outfits for high-altitude flight, for use in the GAMD *Mirage III* and *Mirage IV*. An experimental outfit was made and certificated under the name EFA type 12 helmet and type 22 suit; this has now been ordered and is being manufactured in quantity. During a second development programme, EFA made a new outfit, known as EFA type 30. Designed to ensure the safety of flight personnel at altitudes of over 50,000 ft, the outfit consists of the following garments: type 22A or type 30 pressure suit; type 25 aerated underwear; anti-g trousers (used only with type 30 pressure suit —type 22A has built-in anti-g trousers); leather oversuit; pressurized gloves; type 12 pressurized helmet, standard or aerated. The total weight of the EFA type 30 suit is 5.2 lb, medium size.

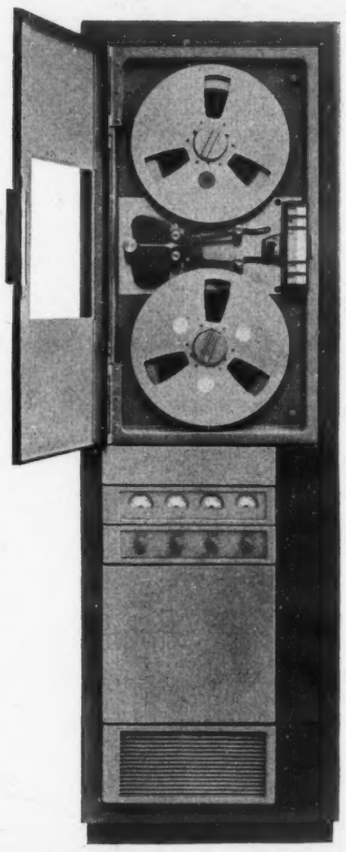
Pilots equipped with the new suit and the type 12 helmet are undergoing tests at the CEV Aero-Medical Laboratory to determine whether the equipment meets NATO specifications. They spend 20 minutes at 60,000 ft simulated altitude, followed by a climb to 70,000 ft, with a three-minute simulated flight at this altitude. To determine the efficacy of the equipment over and above NATO requirements, the following tests were carried out without the performance limits being reached: two hours endurance test at 70,000 ft; an altitude test consisting of a climb to 100,000 ft.

●

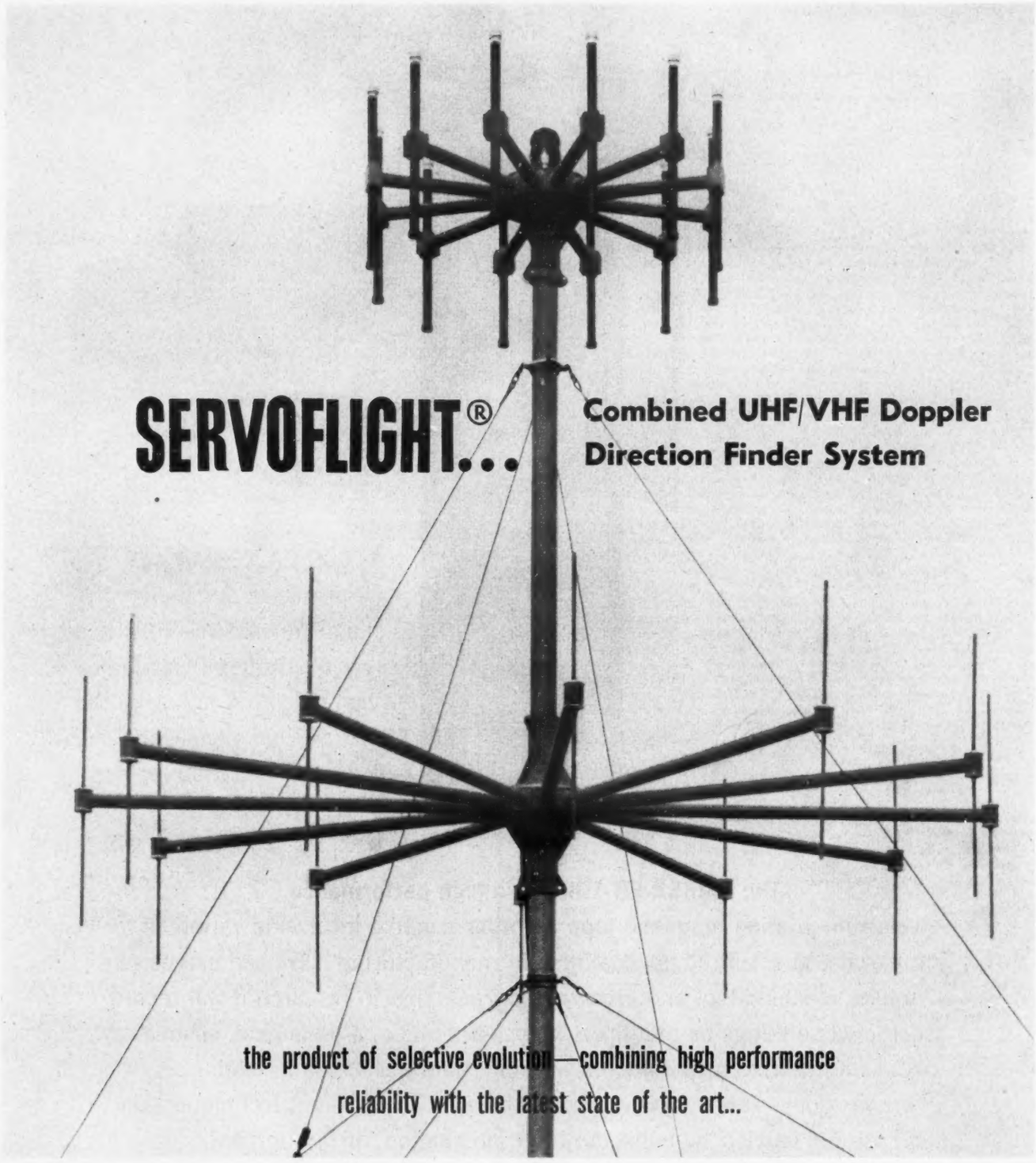
C. Plath GmbH, of Hamburg, has brought onto the market a VHF visual direction finder, which operates on the phase comparison principle on a fixed reception frequency in the air traffic control range between 100 and 156 Mc/s. The equipment has a crystal-controlled oscillator. Presentation is in the form of a fluorescent line on a cathode ray tube; the direction of this line can be read directly from an illuminated bearing cursor.

●

The Sperry Phoenix Co. SP-40 push-button automatic pilot has completed its first formal FAA certification tests aboard the Grumman *Gulfstream* twin-turboprop executive transport. Sperry Phoenix has booked orders valued at over $1 million for the SP-40 system, which is now being delivered in quantity for equipping the Lockheed *JetStar*.



The AMPEX FR-100B is a high performance instrumentation magnetic tape recorder suitable for a wide variety of industrial and scientific applications. In manufacturing it is used extensively in both machine tool and process programming. In research it will record such diverse things as the thrust measurements of a jet engine, cosmic ray counts from a satellite, or vibration data developed in testing a new car body. This information can be recorded by direct techniques, on an FM carrier, by pulse duration modulation, or through NRZ digital techniques. It is capable of recording up to 14 analogue or 16 digital tracks, operates at any of 6 standard speeds from 1⅞ to 60 inches per second... can be modified for other speed combinations. And, depending on the system used, it will record from a direct current signal up to 100 kilocycles, ±3 db. The FR-100B will also reproduce tapes it has recorded, or those made on similar Ampex machines. I. R. I. G. compatible at no extra cost. For complete information on this remarkable recorder write to Ampex Great Britain Limited, Arkwright Road, Reading, Berks., England. AMPEX



SERVOFLIGHT®...

Combined UHF/VHF Doppler Direction Finder System

the product of selective evolution—combining high performance reliability with the latest state of the art...

Utilizing standard **SERVOFLIGHT®** Model 10 UHF and Model 55 VHF units as basic components, this equipment will satisfy a wide variety of operational requirements. A highly versatile, compact Doppler direction finder system that is easy to install and maintain. Wide-aperture antenna provides accurate, reliable bearings even at poor sites.

- **Stacked UHF/VHF antenna configuration**—Designed for installation on buildings, control tower, or directly on ground.
- **Remote control and display**—available for operation over standard telephone lines or radio link.
- **Compact**—Transistorized design, compatible with restricted space availability.

SERVO CORPORATION OF AMERICA

111 New South Road, Hicksville, L.I., N.Y., U.S.A.

Export Representative:
Szucs International Corporation
50 Broad Street
New York 4, N.Y., U.S.A.

FIAT G 91 T

BRISTOL SIDDELEY ORPHEUS 80302 ENGINE

The jet trainer with all the characteristics of the FIAT G 91, NATO's single-seat lightweight strike fighter.
Pilots trained on the G 91 T are ready for assignment to units immediately afterwards.

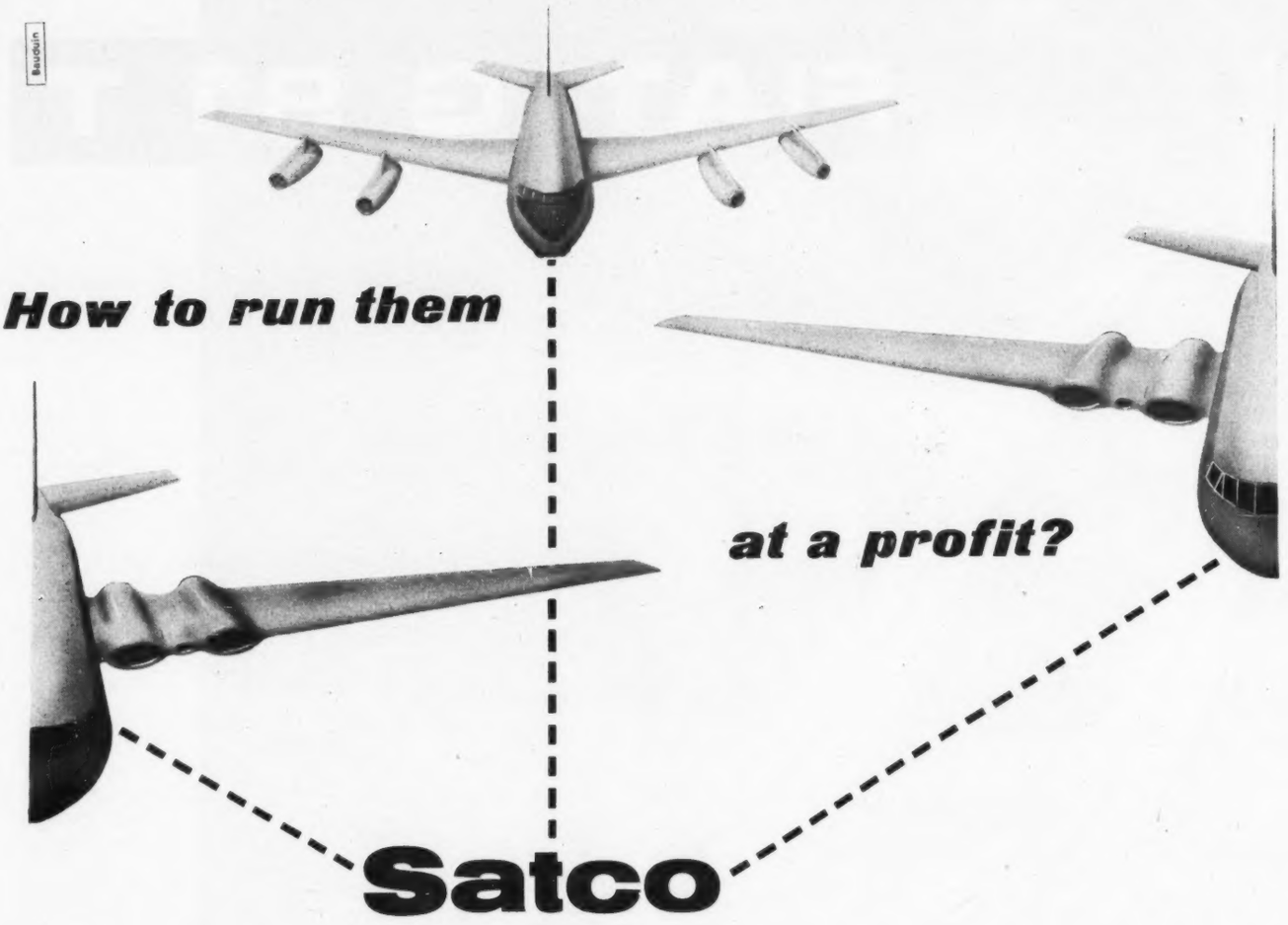
A SINGLE AIRCRAFT SERVES BOTH FOR ADVANCED AND OPERATIONAL TRAINING, AND FOR COMBAT PURPOSES.
Its similarity to the single-seat fighter makes it ideal not only for advanced and operational training, but also for actual operation on ground support and armed reconnaissance missions.

Principal Characteristics

Dimensions:		*Performance:*	
Wing span	28.24 ft	Speed	transonic
Length	39.37 ft	Time-to-climb	
Height	13.94 ft	to 13,200 ft	3 min 20 sec
Weight	11,770 lb	to 24,400 ft	5 min 55 sec
		Range	1,190 n.m.

FIAT DIVISIONE AVIAZIONE - Corso G. Agnelli 200 - TURIN (Italy)

Bauduin



How to run them at a profit?

Satco

signaal automatic air traffic control

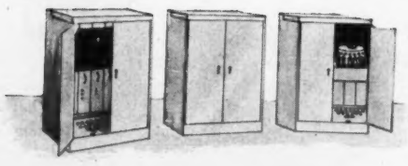
To keep up **financially** with technical advance in the aircraft industry - that is the problem our airline companies have to wrestle with. Modern jet-airliners cost up to £ 2.000.000 each! Every minute an aircraft has to circle an airport means more money; every missed connection, every flight at an unfavourable altitude means more money. And it all costs more, the more expensive aircraft becomes.

SATCO

Automatic Air Traffic Control System will help to reduce these costs.

SATCO

comprises the ground equipment to predict, coordinate, check and display the movements of air traffic en-route and in terminal areas. It provides an extremely rapid method of calculating flight paths, for assessing potential conflicts and for co-ordination between Area Control Centres. Special features are included for military/civil co-ordination and for the control of jet-powered traffic. The system has been ordered by the Netherlands Government, and the first phase is now on operational test.



SIGNAAL

Signaal

N.V. HOLLANDSE SIGNAALAPPARATEN HENGELO - NETHERLANDS

FIGHTER AND STRIKE AIRCRAFT
TO EQUIP THE AIRCRAFT CARRIERS CLEMENCEAU AND FOCH

GÉNÉRALE AÉRONAUTIQUE MARCEL DASSAULT

for "jets"

Kléber-Colombes offers you laminated tyres

These tyres have a patented tread reinforced by superimposed layers of nylon cord incorporated in the rubber. This lamination ensures excellent behaviour at high speeds. It enables thicker treads to be used and increases endurance.

Kléber-Colombes
Aviation

6, Avenue KLÉBER • PARIS-16e

SYMBOL OF QUALITY

Fifty Years of Aircraft Development

Aviation is often described as a new industry, and in consequence the announcement that a company has completed a half century of aircraft manufacturing comes as a sobering thought.

On January 1st, 1961, the Vickers Group celebrated this half century, and a glance at some of the highlights of the past 50 years reveals the many contributions that the company has made both to aviation and aviation history.

The original company of Vickers, Sons and Maxim embarked on an aviation career with the formation of an Aviation Department at Brooklands. This department was created to manufacture and sell aeroplanes designed by the French constructor Robert Esnault Pelterie under an agreement which came into operation on January 1st, 1911.

From this date until the outbreak of war in 1914, the story of the early Aviation Department followed a pattern similar to that of many of the early aviation pioneers. The Vickers Flying School was established at Brooklands in 1912, and design and production of a number of types was carried on by a small design team. Attempts to produce a satisfactory military aircraft at first met with little success, but the early troubles were overcome, and in December 1913 the company received a production contract for what can be described as the first offensive aeroplane ever designed—the *Gunbus*. This aircraft was equipped with a Vickers machine gun in the nose, with a free field of fire, and in early stages of the First World War performed sterling service on the Western Front.

During the war years, the company constructed a large number of military aircraft of various designs, but the most important aircraft to appear from the design offices was not ready for action until November 1918 and was to make its name in peaceful operations.

This aircraft was the *Vimy*, a twin-engined bomber which was to be the first aircraft to cross the Atlantic direct and was to be used on many pioneering flights on routes which are now heavily travelled by commercial aircraft.

In the years between the wars, the company produced many types of both military and civil aircraft in the hope of either military contracts or foreign sales. Up to the early 30s, Vickers supplied the majority of the heavy bombers for the Royal Air Force, in particular the *Vimy* and the *Virginia* and also many of the transports including the *Vernon*, the *Victoria* and the *Valentia*.

A number of civil airliners were also produced during this period, including the *Vimy Commercial*, the *Vulcan* and the first *Vanguard*. The emphasis was, however, on the production of military aircraft, and apart from the heavy bomber production, large numbers of single-engined military biplanes designed for bombing, torpedo dropping and reconnaissance were built. Perhaps the most famous of these were the *Vincent* and *Vildebeest*, which were in service up to the early days of World War II.

The first of many. The Vickers Vimy *which made the first non-stop Atlantic crossing on June 14/15th, 1919.*

The requirement for a long-range bomber for the Royal Air Force in the mid- 1930s provided Vickers with another aeronautical "first." This was the *Wellesley* with its unique geodetic structure. This form of construction was evolved by Doctor B. N. Wallis and was used in the *Wellington*, of which no fewer than 11,461 were built.

At the close of hostilities, Vickers made a rapid change-over from military to civil production and produced the *Viking* as a British civil airliner. This was employed extensively by British European Airways, and further variants were produced for military use. While the *Viking* was going into service, vigorous efforts were being made to develop the VC.2 turbine airliner project which eventually entered world-wide service as the *Viscount*.

Post-war military production has included the *Valiant*, a four-jet bomber which was designed and produced in record time and formed the first equipment of the V-Force of the Royal Air Force. This was the final military aircraft to be designed by the company, prior to its amalgamation with the British Aircraft Corporation.

In the 50 years which have elapsed, Vickers has played an important part in the development of aviation. Many notable firsts and pioneering flights have been carried out in aircraft designed and manufactured by the company. In wartime also, Vickers aircraft have played an incalculable part in re-shaping the future.

The continuation of this 50 year story lies ahead. The *Vanguard* is now entering service to continue the tradition established by the *Viscount*. The next stage will be the arrival of the VC.10 on the long-range jet aircraft routes. This aircraft will commence operation with a half-century of tradition behind it—no small qualification for a newcomer to the scene.

The second to bear the name. A Vanguard *in the livery of BEA. The first Vickers aircraft to bear this name was a twin-engined biplane which made its appearance in 1922.*

INTERNATIONAL MEETINGS AND CONFERENCES

Feb. 13th: IATA, Medical Committee. New Delhi.

Feb. 14th-16th: Society for Non-destructive Testing and Southwest Research Institute, Second Annual Symposium on Non-destructive Testing of Aircraft and Missile Components. San Antonio, Tex.

Feb. 15th-17th: Institute of Radio Engineers, International Solid-State Circuits Conference. Philadelphia, Pa.

Feb. 27th-28th: Canadian Aeronautical Institute, Mid-Season Meeting. Winnipeg, Man.

Mar. 5th-9th: American Society of Mechanical Engineers, Sixth Annual Gas Turbine Conference and Exhibit. Washington, D.C.

Mar. 9th-10th: Institute of the Aerospace Sciences, Flight Propulsion Meeting. Cleveland, Ohio (classified).

Mar. 9th-10th: University of Pennsylvania, Second Symposium on Engineering Aspects of Magnetohydrodynamics. Philadelphia, Pa.

Mar. 12th-16th: American Society of Mechanical Engineers, Aviation Conference. Los Angeles, Calif.

Mar. 13th-15th: American Rocket Society, Flight Testing Conference. Los Angeles, Calif.

Mar. 13th-16th: American Rocket Society, Test, Operations and Support Conference. Los Angeles, Calif.

Mar. 13th-22nd: International Spring Fair. Utrecht.

Mar. 14th: ICAO, Subcommittee of the Legal Committee on Aerial Collisions. Paris.

Mar. 16th-18th: Fifth National Conference on Aviation Education. Washington, D.C.

Mar. 20th-23rd: Institute of Radio Engineers, International Convention. New York, N.Y.

Mar. 20th-24th: American Society for Metals, Western Metal Exposition. Los Angeles, Calif.

Mar. 27th-31st: Instrument Society of America, National Symposium on "Temperature—Its Measurement and Control in Science and Industry." Columbus, Ohio.

Apr. 4th-6th: International Symposium on Electromagnetics and Fluid Dynamics of Gaseous Plasma, sponsored by IRE, IAS and U.S. Defense Research Agencies. New York, N.Y.

Apr. 4th-7th: Society of Aeronautical Engineers, National Aeronautical Meet. New York, N.Y.

Apr. 5th-7th: American Rocket Society, Lifting Re-entry Vehicles: Structures, Materials and Design.

Apr. 8th-16th: Singapore Government, International Air Show. Singapore.

Apr. 10th-11th: Western States Section of the Combustion Institute, Aeronutronics Division of Ford Motor Co., Spring Meeting. Newport Beach, Calif.

Apr. 17th: International Airport Association, 14th Technical Conference. Montreal.

Apr. 17th-28th: IATA, 14th Technical Conference. Montreal.

Apr. 18th: IATA, Legal Committee. Paris.

Apr. 18th-20th: Airlines Electronic Engineering Committee, Maintenance Meeting. Atlanta, Ga.

Apr. 18th-20th: Stanford Research Institute, Symposium on Chemical Reactions on the Lower and Upper Atmosphere. San Francisco, Calif.

Apr. 18th-28th: ICAO, Origin and Destination Statistics Panel, Third Meeting. Paris.

Apr. 20th-21st: 18th Annual SPI Western Section Conference. Coronado, Calif.

Tug-of-War over Skybolt

This year as in other years, the budget debates in the Pentagon, which were conducted with their usual vigour, raised such a tempest that a number of projects perished in the waves. Among the most controversial projects was the *Skybolt* air-to-surface ballistic missile which could, claim Douglas and the U.S. Air Force, be in service with Strategic Air Command from 1964 onwards. Although *Skybolt* is often spoken of as the successor to the North American GAM-77 *Hound Dog*, there are considerable differences between the respective roles of the two missiles. In any case, *Skybolt* is assuming a significant position in the USA's strategic concept (cf. *Interavia* No. 7/1960, page 808 *et seq.*, and No. 12/1960, page 1528 *et seq.*). The carrier aircraft is to be the B-52H, the newest version of the Boeing long-range bomber, powered by eight Pratt & Whitney TF-33 turbofan engines, which should increase its range considerably above the 10,000 miles of the B-52G. Under an Anglo-American agreement signed last year, Great Britain will also be taking part in the *Skybolt* project, using the Avro *Vulcan* as carrier aircraft.

The sum of $2,370 million was originally appropriated for the development of *Skybolt*; $185 million have so far been spent. At the end of December, 1960, the U.S. Air Force requested a further credit of $150 million for the next fiscal year (beginning on July 1st, 1961). At the same time, however, voices were raised in the Pentagon against the *Skybolt*; certain circles are said to prefer a developed version of the *Hound Dog*. There may be some connection between the criticisms of *Skybolt* and rumours that one or more firms are engaged on the development of an air-to-surface missile for the North American B-70 supersonic bomber; to equip the B-70 with the *Skybolt* would require such extensive modifications to the missile that it would have to be virtually redesigned.

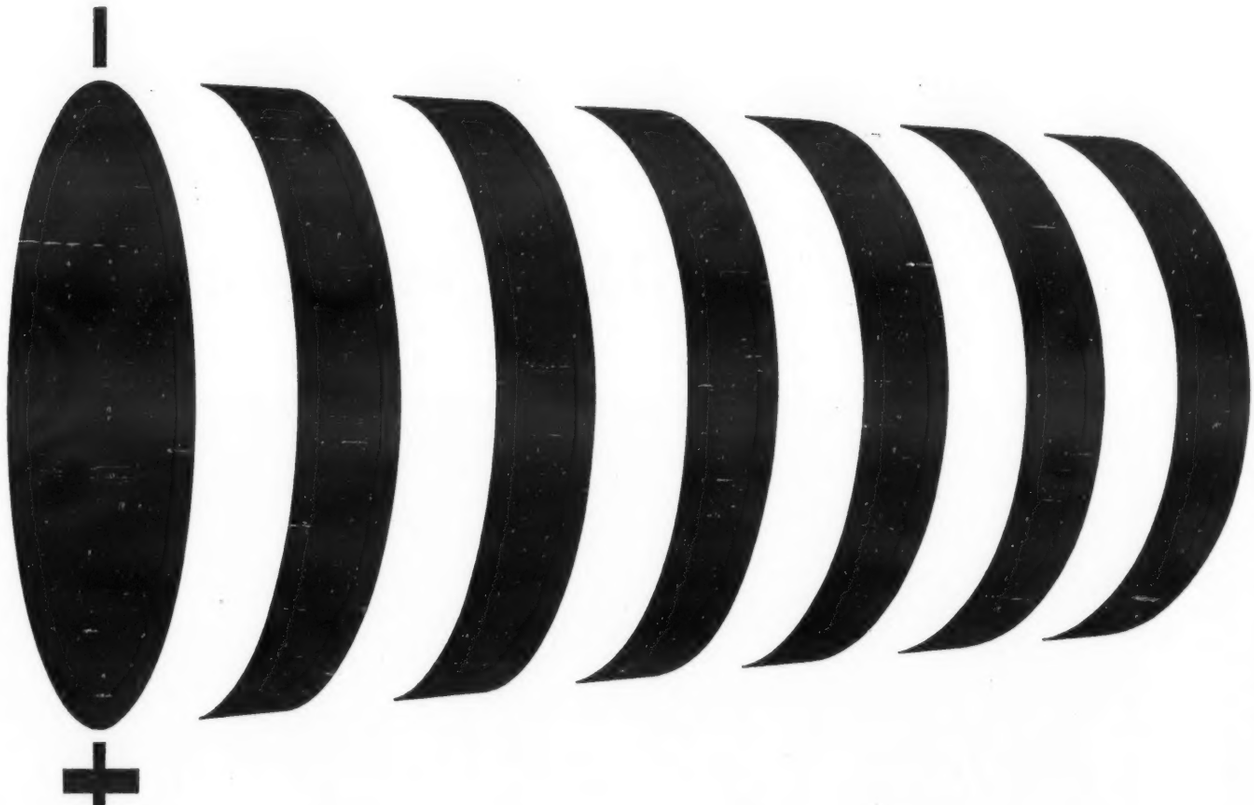
Not only in the Department of Defense, but also in the Air Force, there are those who accord less urgency to *Skybolt* than hitherto. Certain Air Force circles would rather see the project in the hands of the Ballistic Missile Division, which is responsible for all other USAF missile projects, than with the Wright Air Development Division. Other rumours have it that various USAF departments in the Pentagon are interested in entirely new weapon concepts, including a strategic space bomber of global range, which would operate at relatively low orbital altitudes, and a space bomber which would operate at a great distance from the earth.

Just before the turn of the year it was learnt that, although the continuation of the *Skybolt* project was assured, just over half the $150 million appropriation applied for—about $80 million—would be available during fiscal 1962. There can be no doubt that a cutback of this magnitude would considerably delay the programme, and that the dates on which the missile is scheduled to become operational—1964 for the U.S. Air Force, 1965 for the RAF's V-bomber force—would also very likely be postponed.

At the beginning of January, however, the Defense Department and the Air Force came to an agreement whereby the programme could be continued in its full scope, at any rate for the time being. By cutting the appropriations for other budget items, the Air Force will obtain an additional credit of $70 million, which will give it the $150 million originally requested. This sum is to last the USAF until June 30th, 1962, says the Defense Department; how the Air Force is to spread expenditure over this period is a matter entirely for its own discretion. According to reports from Washington and London, the USAF intends to force ahead with the project at full pressure, in other words, to spend the credits during the current fiscal year and to press the Kennedy administration for additional funds for fiscal 1962. In London, at any rate, there seems to be no lack of confidence; a *Vulcan* is reportedly already in the USA for preparation to take the *Skybolt*.

In the meantime, there has been news of the draft defence budget for the next fiscal year, which President Eisenhower submitted to Congress four days before the end of his term. This makes provision for expenditure of $42,900 million, $1,400 million more than in the current fiscal year, but still falls $1,000 million below the total requested by the three armed services. The Air Force again has the lion's share of the defence appropriations, with $19,300 million (45 percent), while the remainder is distributed as follows: $10,400 million (24.3 percent) for the Army, $11,900 million (27.7 percent) for the Navy and $1,300 million (3 percent) for the Defense Department. Now that President Kennedy has taken over the affairs of State, it remains to be seen how far he will modify the draft defence budget of the Eisenhower administration. Certainly, Kennedy has left no doubt at all that he intends to put future United States policy on a highly realistic footing. In other words, it can be assumed that he will hold firm to the concept of deterrent strategy in the immediate future, and any programme which fits into this concept has good prospects of financial backing. This should ensure that the *Skybolt* project is continued for some time to come.

A Boeing B-52H with four models of the Douglas Skybolt *air-to-surface ballistic missile under its wings, at Boeing Airplane Company's Wichita, Kansas, airfield. The B-52H made its first flight with* Skybolt *experimental models on January 12th, 1961; this was designed to test the aerodynamic compatibility of aircraft and missiles.*



All clear for a safe take-off

Today - in the age of arrow-swift jet aircraft - flight safety requirements are more stringent than ever before. Here, too, Daimler-Benz AG is giving assistance with its comprehensive range of special airport vehicles. These are the result of many years of close cooperation between airport authorities all over the world, makers of special equipment and the world's first automobile manufacturers, Daimler-Benz AG. We can offer you:

Airport Service

Unimog with lawn-mower attachment · Unimog with attachments for building work, technical and transport tasks · Unimog and truck with various types of snow plough, including rotary snow ploughs · Runway sweepers with de-icers

Aviation Service

Passenger vehicles · Airfield refuelling trucks · Pumping vehicles for hydrant refuelling · Folding ladders for maintenance

Emergency Equipment

Fire extinguishers using water, foam, powder, CO_2 · Water trucks · Foam trucks (with hydrant connection) · Rescue vehicles · Ambulances · Mobile cranes

MERCEDES-BENZ

15 YEARS OF TRAFFIC MOTORIZATION 1886 1961

170 LA

How to fly through

a needle's eye

Precise navigation to a given destination has been, and continues to be, a major problem for both military and commercial aircraft.

In the early days of flying, pilots flew low to follow roads and railroads. Later, with radio, they were guided by voice contacts. Then the radio beam was developed.

But, in all these, there has been dependence on *external* help.

Today, with a new Hughes electronic navigation system, a pilot can literally fly "blind" to any spot he chooses. He can fly at supersonic speeds, even at very low altitudes. He can fly in any weather. He need never see the ground or sky.

This new system can achieve very accurate weapon placement with a wide variety of armament even under adverse weather conditions.

This system is called TARAN, a veritable "flying brain" with amazing aptitudes, incorporating several new achievements in the electronic art. It has a radar system with several times the range and resolution of current radars. It has an automatic navigation system which provides the pilot with a continuous picture of his position on a moving map display. It has a unique terrain clearance system which warns the pilot of any obstacles when he is flying at low altitude. And all of this capability is in a small, light-weight "package," with low first costs—low maintenance costs.

TARAN is but one example of Hughes pioneering advances in the state of the electronic art. Other Hughes achievements include electron tubes that can "freeze" pictures and "remember" images, parametric amplifiers that increase radar's range for better air traffic control, solid state radiation detectors that will bring far-reaching benefits in the fields of industrial processing and medicine, an "atomic" clock that can test Einstein's theory of relativity—just to name a few.

Perhaps you can benefit from major engineering and scientific efforts such as these. We invite your inquiry on how Hughes can help you improve your present product or develop your ability to produce more profitably.

The Moving Map Display *provides the pilot with continuous position and course information. At each designated check point, the system automatically checks the map position against the radar display and makes the necessary flight corrections.*

HUGHES INTERNATIONAL
A DIVISION OF HUGHES AIRCRAFT COMPANY
CULVER CITY, CALIFORNIA, U.S.A.

THE PROMENADE BAR

AIR FRANCE EXCLUSIVE TO NORTH AND SOUTH AMERICA, AFRICA, ASIA

A FEATURE OF FIRST CLASS JET FLIGHTS

At an altitude of 32,000 feet, you can relax and chat with your fellow-passengers in this smart lounge bar aboard Air France's Boeing Intercontinental jetliners. While you enjoy your favorite drink in an atmosphere of distinctive elegance, the miles slip by and your trip seems even shorter! This Promenade Bar is an exclusive Air France facility for First Class passengers on all routes served by Boeing Intercontinentals, including notably Paris - New York (8 hours), Paris - Los Angeles (13 hours 30 minutes) and Paris - Tokyo (17 hours).

Other innovations in First Class are food and wine specialties of the French provinces, and the new extra-large King-Size armchairs.

In addition to First Class accommodations on all Boeing Intercontinental flights, Air France now offers Tourist Class and Economy Class facilities — less luxurious, but at very advantageous fare rates. *For details, see your Travel Agent or enquire at your nearest Air France office.*

AIR FRANCE

BOEING INTERCONTINENTAL AND CARAVELLE, PERFECTION IN JET TRAVEL ON THE WORLD'S LARGEST AIRLINE

RADAR

50 cm Gives longer range for given transmitter power.
The Marconi series of 50 cm radars gives clearance of jet aircraft from take-off to 150 miles plus on a power of only 500-600 kW. The one radar meets both airways surveillance and air traffic control requirements. Running costs are thus much lower.

50 cm Penetrates thick weather without loss of efficiency.
In most radars precipitation clutter seriously obscures the PPI picture. No remedial device is 100% efficient. The choice of the 50 cm wave length, however, avoids the difficulty entirely. It gives a clear picture of aircraft, even in heavy rain or snow, and also indicates the position of storm centres.

50 cm Permits M.T.I. elimination of permanent 'clutter'.
Of the various ways of clearing the echoes of stationary objects which confuse the interpretation of the radar situation, M.T.I. (moving target indication) undoubtedly gives the best results. The use of 50 cm makes it possible to use crystal control throughout a radar system to which a simple and completely stable M.T.I. can be harnessed to give a clear and unambiguous picture.

50 cm Switches into instant operation.
Crystal control of frequency enables Marconi 50 cm radar to be brought into instant operation even after long periods of inactivity.

GIVES THE LONG, CLEAR VIEW

MARCONI

COMPLETE CIVIL, MILITARY AND NAVAL RADAR SYSTEMS

SURVEYED, PLANNED, INSTALLED, MAINTAINED

MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED · CHELMSFORD · ESSEX · ENGLAND

Fully evaluated under actual airline flight conditions...

Champion's new jet igniters double igniter service life in Douglas DC-8, Boeing 707 and 720 engines!

Champion's new igniters for JT3 and JT4 engines —firing under the new engine operating procedures calling for continuous ignition for longer periods— exceed twice the service life of any other igniter available!

A little more than a year ago, when the requirements of an advancing jet age recommended new engine operating take-off procedures calling for continuous ignition for longer periods, it was discovered that standard igniters were not capable of handling the increased requirements. They suffered severe electrical erosion. They burned out—rapidly!

A new type of jet igniter was needed, as quickly as possible. Champion accepted this challenge; and today, after more than a year of research design and development; Champion makes these new jet igniters available to all Douglas DC-8, Boeing 707 and 720 operators.

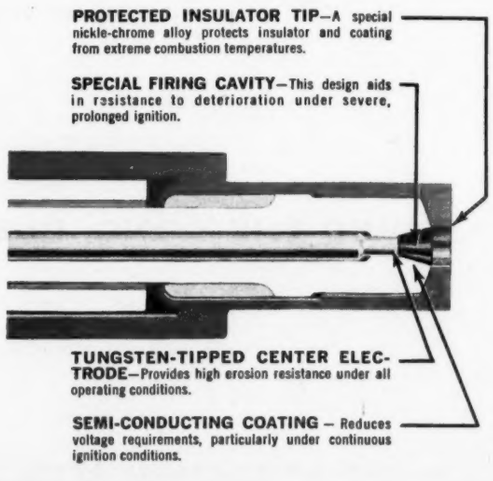
Thoroughly tested, approved by Pratt & Whitney and the FAA, and extensively evaluated in flight, Champion's new AA37S and AA42S igniters are *doubling* jet igniter service life!

The reason for this far longer service life is found in the igniters' firing-end design, shown below. This design, along with improved metals and ceramics, gives the new igniters their remarkably high resistance to the electrical inferno that chips ceramics and erodes metals.

The new Champion AA42S igniter is approved for the JT4 engine and replaces the Champion AA16S. The new Champion AA37S igniter is approved for the JT3 engine and replaces the Champion AA15S. And the AA37S is the *only* igniter approved for the new, powerful JT3D turbo-fan engine!

These new jet igniters are examples of Champion's continuing and unequaled contribution to the needs of jet-engined and piston engined aircraft. For the most dependable, best performing aviation spark plugs available today, always insist upon Champion!

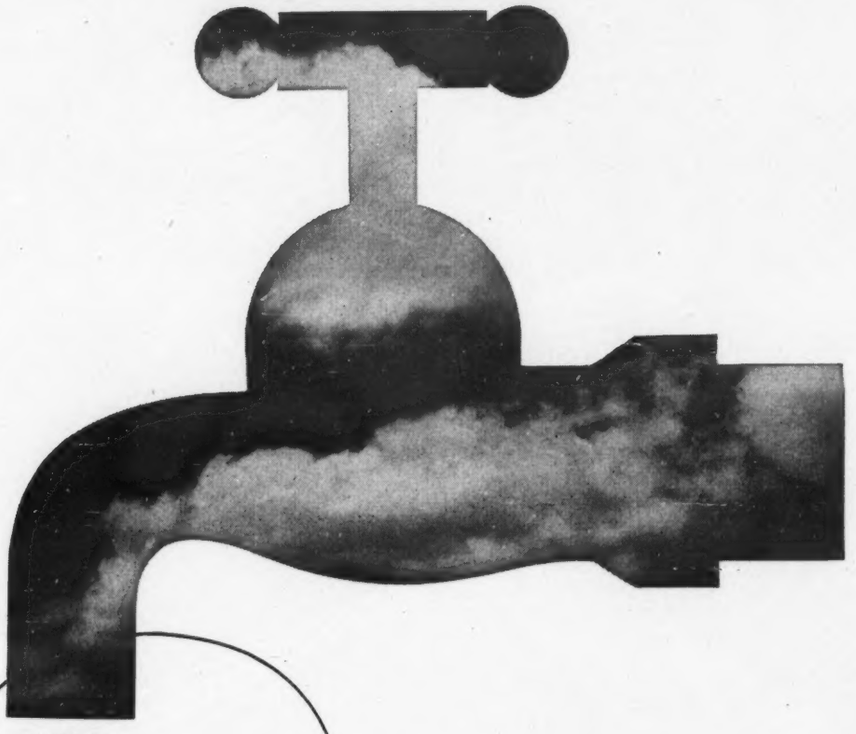
Design features of the AA37S and AA42S Champion jet igniters


PROTECTED INSULATOR TIP—A special nickle-chrome alloy protects insulator and coating from extreme combustion temperatures.
SPECIAL FIRING CAVITY—This design aids in resistance to deterioration under severe, prolonged ignition.
TUNGSTEN-TIPPED CENTER ELECTRODE—Provides high erosion resistance under all operating conditions.
SEMI-CONDUCTING COATING — Reduces voltage requirements, particularly under continuous ignition conditions.

WORLD'S FAVORITE SPARK PLUG ON LAND, SEA AND IN THE AIR

DEPENDABLE **CHAMPION** SPARK PLUGS

CHAMPION SPARK PLUG COMPANY: ENGLAND, U.S.A., CANADA, AUSTRALIA, IRELAND, FRANCE, MEXICO, BRAZIL



NOW! WEATHER INFORMATION FOR THE PILOT ON TAP BY TELEPRINTER

THE MARCONI AD308 TRANSISTORISED AIRBORNE TELEPRINTER RECEIVER

AD308 provides automatic teleprinting of continuously broadcast weather information whenever the pilot needs it.

AD308 high selectivity receiver and low noise ferrite loop aerial gives continuous reception across the North Atlantic.

AD308 using narrow band L.F. reception clears the HF band for vital ATC communications.

AD308 being automatic, radically reduces the flight deck work load.

AD308 light weight receiver is contained in a short ½ A.T.R. case and weighs only 9 lbs (4.1 Kgs).

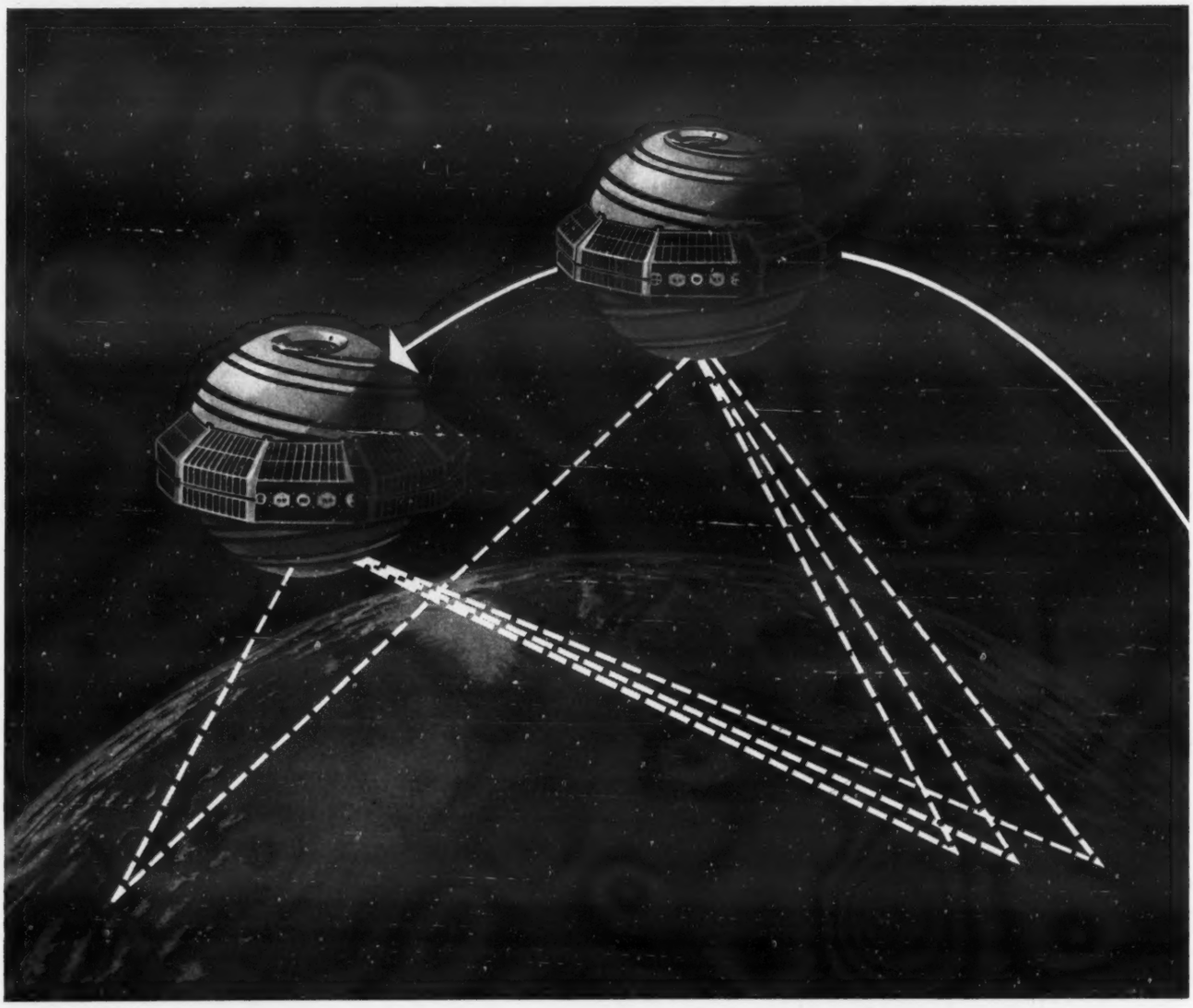
* *Fitted in B.O.A.C's. fleet of Boeing 707's*

MARCONI

AIRPORT AND AIRCRAFT RADIO SYSTEMS

MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED · CHELMSFORD · ESSEX · ENGLAND

A1



Now! Cubic SECOR can determine intercontinental distances with unprecedented accuracy!

Even the best present-day maps show intercontinental distances with uncertainties as high as 700 feet. Cubic's Geodetic SECOR, developed under United States Army sponsorship, can ultimately measure these distances so accurately that the relative location of the Statue of Liberty and the Eiffel Tower will be known to within a few feet!

SECOR experiments for the Army Map Service, starting with a cooperative program involving Navy TRANSIT satellites, will also determine the true shape of the earth. Here's how SECOR works:

Three SECOR stations are located 500 to 1000 miles apart, at the accurately-surveyed corners of a triangle. A fourth SECOR station is situated at the point, up to several thousand miles away, whose precise location is of interest. Each of the four ground stations determines its distance, within a few feet, from an orbiting satellite which carries a small SECOR transponder. (The ground stations measure the phase displacement between modulation signals transmitted to, and returned from, the transponder. This displacement is directly proportional to the satellite's distance.) It is then a simple matter to compute the exact position of the fourth station with respect to the other three.

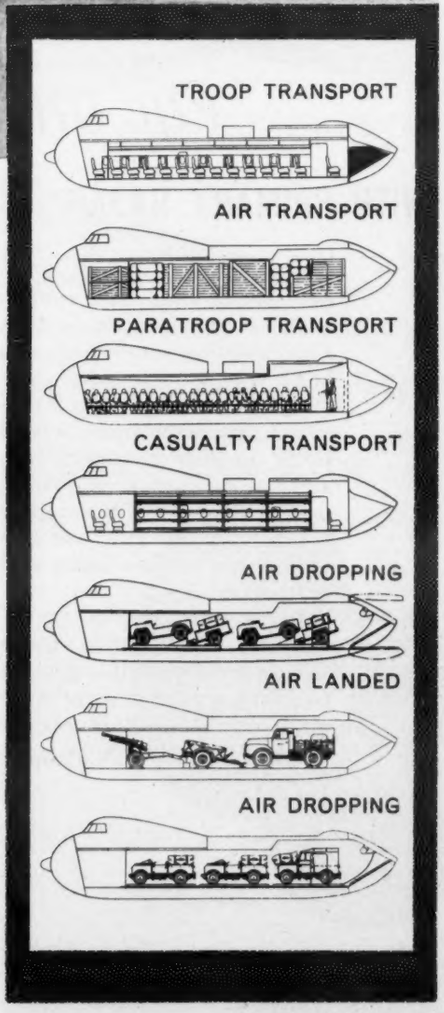
Other SECOR applications include global navigation of ships and aircraft, missile range instrumentation, and space navigation of lunar and interplanetary vehicles.

For a brochure on Geodetic SECOR, or information on challenging engineering positions now open at Cubic, write to Dept. SA-3, Cubic Corporation, San Diego 11, California.

cubic
CORPORATION

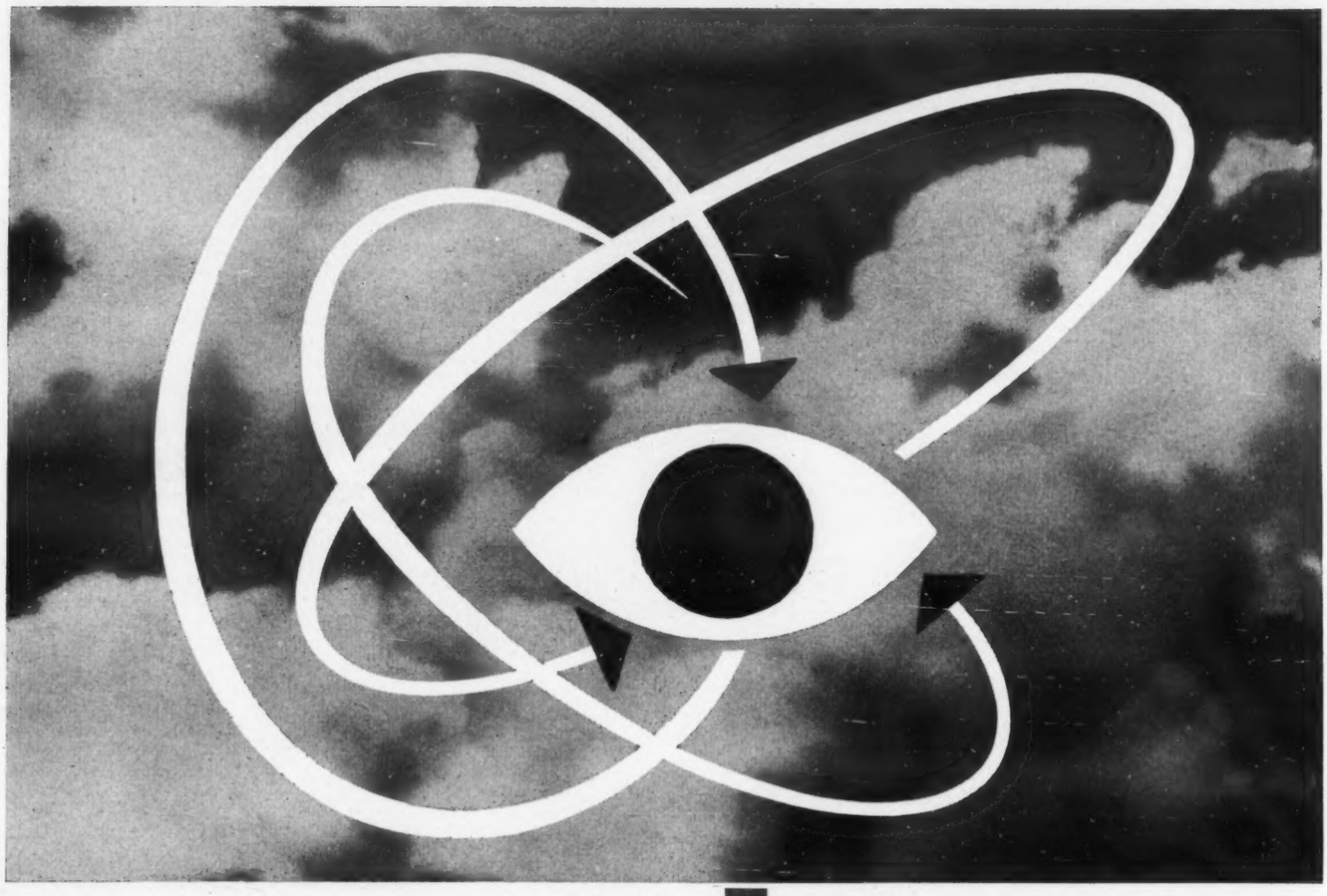
AW.660 MILITARY TRANSPORT

The modern Army's most dependable work-horse, the AW.660 carries anything—from 69 fully-equipped troops to 13 ½ short tons of artillery, lorries, trucks, etc. The large rear freight door facilitates simultaneous loading of troops and equipment; turnround is reduced to 20 minutes. The AW.660 is fully pressurised and power is supplied by four Rolls-Royce Dart turbo-prop engines. Components and systems have been specially selected for ease of maintenance; the aircraft can fly long periods between overhauls. The AW.660 is utterly dependable under combat conditions and is especially suitable for para-dropping operations.



HAWKER SIDDELEY AVIATION

32 Duke Street, St. James's, London, S.W.1.



eye on the sky

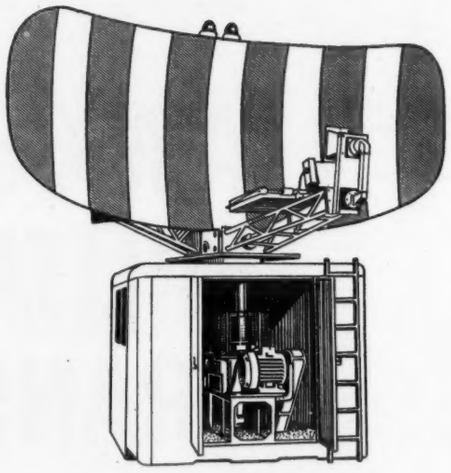
WITH PRIMARY RADAR

Cossor manufacture the CR.787, a medium power S-band Surveillance Radar. This equipment is suitable for use in almost any climate from the Arctic to the Equator. A major feature is the extremely low receiver noise figure which is achieved by using a microwave pre-amplifier. The CR.787 is fitted with M.T.I. to eliminate permanent echoes. Circular polarization facilities are also provided, giving excellent discrimination against rain echoes.

Air route monitoring, local early warning and air traffic control come within the scope of this equipment. Because of high resolution and excellent minimum range performance it is also highly suitable for use in ground assisted landings.

Cossor, who developed the CR.787 as an entirely private venture, have recently had the distinction of receiving an order from the United Kingdom Ministry of Aviation for a substantial number of equipments. The equipment will be used by the Royal Air Force.

The CR.787 is available in mobile form or as a static installation.



COSSOR

RADAR AND ELECTRONICS LIMITED

ELIZABETH WAY · HARLOW · ESSEX · TEL: HARLOW 26862

You'll Get Airborne Safely

and Land Safely, too . . .

on Firestone Sky Champion Tires

Records Prove 8 to 11% More Landings Per Tire

From the smallest to the largest plane, you'll get more runway safety when the wheels are equipped with Firestone Sky Champion tires. And you'll save money too – records prove it. A major air line keeps accurate tire performance records. Their records show that Firestone tires outperformed all others by 8 to 11%.

Your brakes and wheels are no better than the tires that grip the runway.

Here's why Firestone Sky Champions provide better traction and more safety;

1. Flatter Profile
2. Skid Resistors
3. Safety Engineered Tread
4. Exclusive Shock-Fortified Nylon Cord Body
5. Firestone Rubber-X, the longest-wearing rubber ever used in Firestone tires.

Ask for the new Firestone Aircraft tire technical data book.
See your Firestone distributor or write to

FIRESTONE INTERNATIONAL COMPANY, Akron 17, Ohio or
FIRESTONE TYRE & RUBBER CO. LTD., Brentford, Middlesex, England

PIPER OFFERS TWO

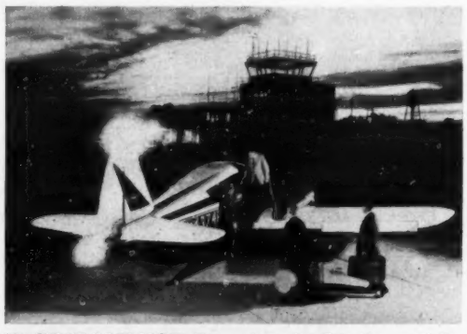
Thoroughly Proven Twin-Engine Aircraft Chosen the World Over for their Reliability and Economy

PIPER AZTEC, newest, largest, fastest of the Piper twins, cruises over 200 miles-per-hour. With a one ton useful load it can carry five passengers, complete radio and instrumentation, and full 144 gallons of fuel. It is powered by two 250 hp Lycoming engines, has very high single-engine ceiling: 10,500 feet at 4,400 pounds; 8,800 feet at 4,800 pounds gross weight. The *Aztec*'s cabin is quiet, roomy, luxuriously appointed.

PIPER APACHE G, newest version of the world's most popular twin-engine executive aircraft, cruises over 170 mph, with range up to 1,260 miles. Carries four or five passengers. Powered by two 160 hp Lycoming engines, it is among the most economical twin-engine aircraft to own, operate, and maintain.

IN MILITARY USE Piper Aztec is in use with the United States Navy for general utility purposes.

Whether you choose the Piper *Aztec* or the Piper *Apache G*, your new Piper twin will bring you these world-famous features: Safe, easy flying characteristics; outstanding short field ability; rugged construction; big, husky landing gear with large-size nose wheel for safer operations in soft, rough fields; reliability, and minimum maintenance.



IN CIVILIAN USE Piper Apache G is the world's most widely used executive twin-engine airplane; selected by the College of Air Training, Hamble, England, for all twin-engine training of pilots destined for the airlines of the United Kingdom.

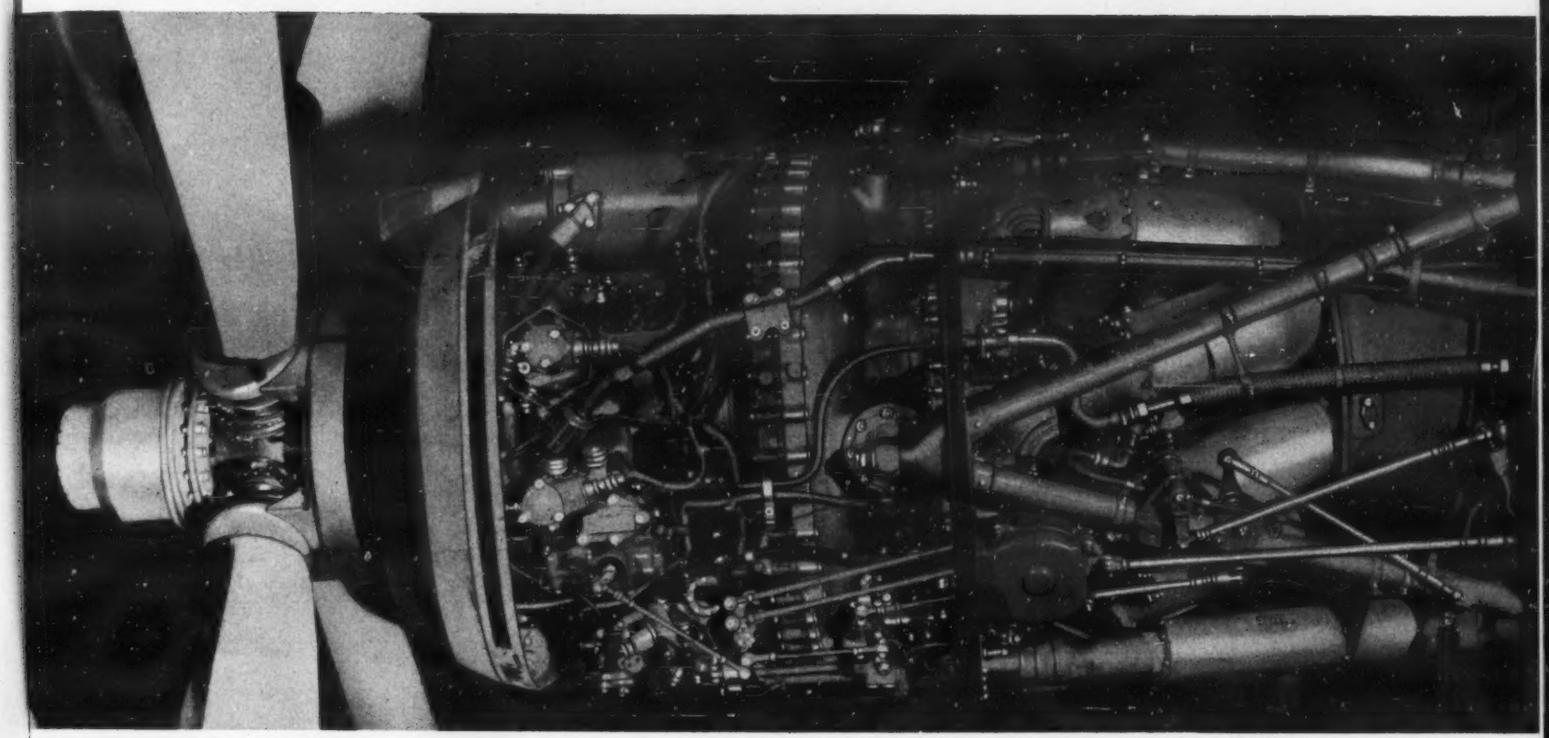
IN GOVERNMENT USE Piper Aztec was selected by the Canadian Department of Transport, which also operates five Piper Apaches for inspection duties, training, accident investigation, and transportation.

PIPER **AIRCRAFT CORPORATION**
Lock Haven, Pennsylvania, U.S.A.

EUROPEAN DISTRIBUTOR:
JONAS AIRCRAFT CORP.
6, rue Lamennais, Paris, France

DISTRIBUTOR FOR THE UNITED KINGDOM
VIGORS AVIATION LIMITED
Kidlington Airport, Oxford, England

Smiths are in the picture



For this Dart R.Da.11 engine, as for all Dart engines, Rolls-Royce approve Smiths long life K.L.G. igniters. Smiths also supply the complete tailor-made Dart thermocouple harness, besides such items as Oil Pressure Transmitters and Indicators, Engine Speed Generators and Indicators, Fuel Pressure Switches and a host of associated engine instrumentation.

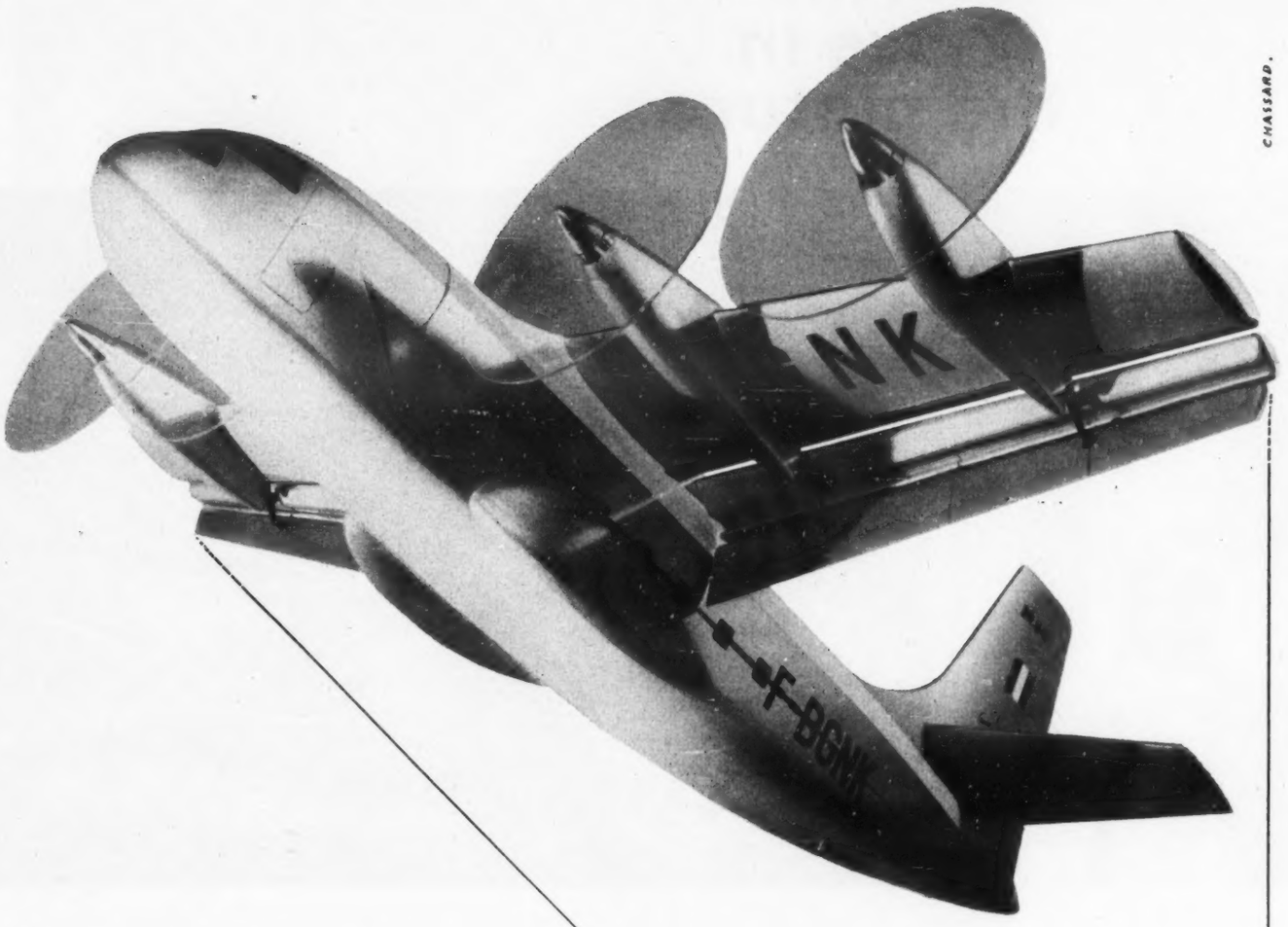
In aviation, Smiths—a name with a world of meaning — means one organisation superbly equipped and backed by extensive design, research and engineering facilities. One contact to solve all your instrumentation problems whether they are engine, navigation, fuel measurement or flight control. If it's instrumentation, Smiths can put you in the picture.

This KR-104 high energy igniter is fully approved by the British Air Registration Board and Rolls-Royce Ltd. for use on all marks of Dart engines. During recent exhaustive laboratory tests, the KR-104 life hours were proved to be three times higher than previous types.

SMITHS **AVIATION DIVISION**

Kelvin House, Wembley Park Drive, Wembley, Middlesex, England
Telephone WEMBLEY 8888
Telegrams AIRSPEED, WEMBLEY. *Telex* 25366

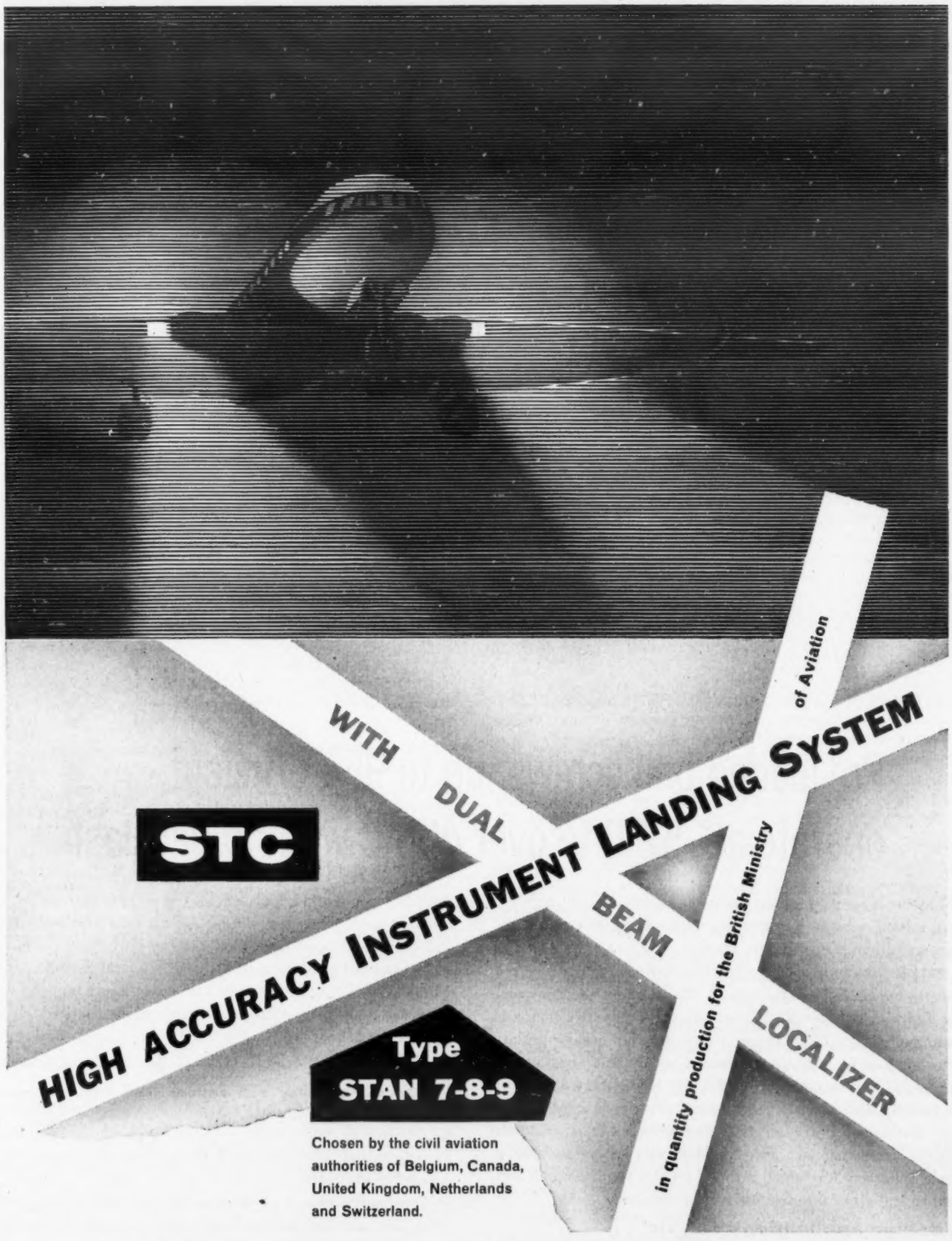
TGA 5M79D



CHAISARD.

Outside the existing network of major air routes with the long runways required by conventional airliners, the BREGUET 941 is in its element ; designed to operate from small, unprepared landing grounds, it can carry, at a speed of 250 m.p.h., not only 40 comfortably seated passengers but also an impressive volume of freight (as much as 5 tons on 1,000-mile stage lengths). The BREGUET 941 will bring air transport to areas hitherto inaccessible owing to the absence or inadequacy of landing grounds, thus giving airlines almost unlimited scope for their activities.

BREGUET 941


HIGH ACCURACY INSTRUMENT LANDING SYSTEM
WITH DUAL BEAM
LOCALIZER
in quantity production for the British Ministry of Aviation
STC
Type
STAN 7-8-9
Chosen by the civil aviation authorities of Belgium, Canada, United Kingdom, Netherlands and Switzerland.

COMMUNICATIONS GROUP

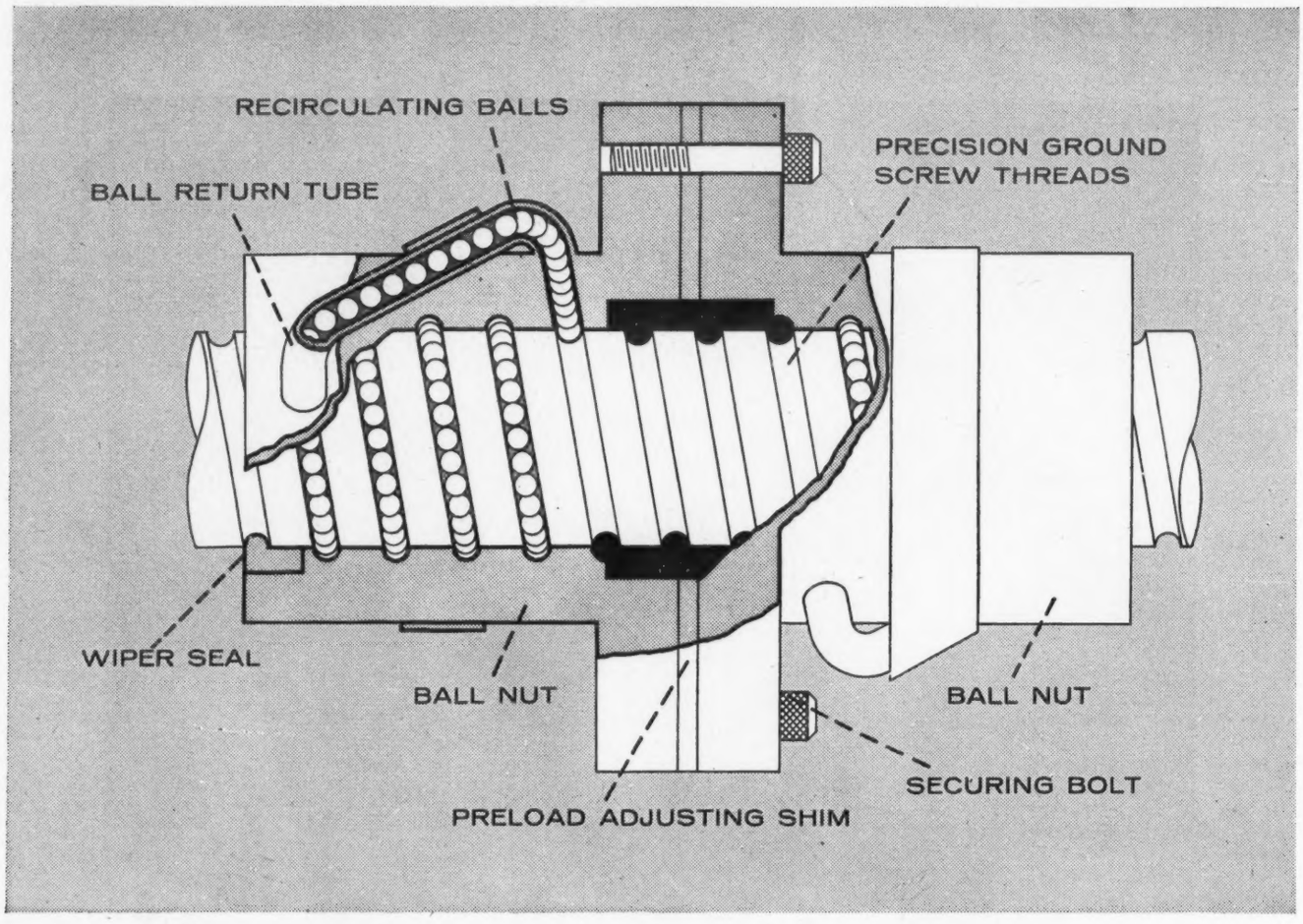
61/IE

Standard Telephones and Cables Limited

Registered Office: Connaught House, 63 Aldwych, London W.C.2

RADIO SYSTEMS DIVISION · OAKLEIGH ROAD · NEW SOUTHGATE · LONDON, N.11

ITT ASSOCIATE



Pre-loaded ball screws, up to 95% efficient, operate at -52°C to over 400°C with no backlash

Bristol Siddeley Engines Limited produce pre-loaded ball screws.* These ball screws achieve a minimum efficiency of 90% and they can operate within a temperature range of —52° C to 400° C without lubrication, and up to 170° C when lubricated.

Machined and ground to the highest standards of precision engineering Bristol Siddeley pre-loaded ball screws greatly increase transmission efficiency. They reduce the power required for actuation by as much as 80%, when converting rotary drive into linear output or force input into torque output. By eliminating backlash, with pre-loading, they give precise control over very small increments of motion and a high response frequency. And when compared to conventional screw mechanisms, they provide a predictable operating life which is much longer, require much less maintenance and give more trouble-free operation.

Basic design application analysis

Bristol Siddeley engineers make an exhaustive analysis of each specification. And each unit is specially designed for its particular application. The ball screws are made automatically reversible or with controlled "no-back," with multiple or single circuits, Bristol Siddeley pre-loaded ball screws have been proved as the most efficient method of converting rotary into linear thrust in over 2,700 engineering applications in many branches of industry. They have been designed already with rated operating load capacities of 370,000 lb (825,000 lb maximum static load) but the maximum potential operating load is, in most cases, limited only by the requirement.

Bristol Siddeley ball splines have been developed to eliminate the disadvantages of conventional splines. The designs are very effective in minimising friction, particularly when high torsional and bending loads are imposed during linear movement.

**Complete technical and manufacturing co-operation with Beaver Precision Products Inc, Detroit.*

For further information please write to J. B. Starky, Sales Manager (Ball Screws and Splines), Bristol Siddeley Engines Limited, PO Box 17, Coventry, England.

BRISTOL SIDDELEY ENGINES LIMITED

AGENTS IN AUSTRALIA: THE BRISTOL AEROPLANE COMPANY (AUSTRALIA) PTY LIMITED, PO BOX 4, BANKSTOWN, NSW, AUSTRALIA.
AGENTS IN HOLLAND: ROEPRS ZOOM, NUNSPEED, HOLLAND. AGENTS IN DENMARK: E. BONDY, POLDBODGADE, 10, COPENHAGEN

The New Jets and Their Demands

Anyone speaking of the future of air transport in this age of sweeping technical change, succumbs all too easily to the temptation to skip all the intermediate stages and begin at the "rocketliner," poised ready for take-off, which can carry its passengers from London to New York within an hour.

The present issue of *Interavia* deals with the future of air transport and the airliner. It covers a very wide span of time and discusses trends which are expected to continue for a decade or more. But those who are hoping for spectacular revelations from the articles which follow will be sorely disillusioned, for not a word is said of passenger-carrying rockets or of nuclear-powered airliners.

Nor has any mention been made of the less sensational topic of supersonic transport, on which many of today's forecasts are based. This will be the subject of a later issue of *Interavia*. The reason for this is that nearly all serious-minded experts agree that at least ten years must elapse before the first supersonic airliners can be placed in service. Furthermore, any statements made today on subsonic transport will retain their validity for at least a decade. Even when supersonic transport is inaugurated, it will not oust subsonic transport, but supplement it.

In any case, the subject of air transport needs no fantastic adornment. What has so far been achieved, and what may reasonably be expected in the foreseeable future, is remarkable enough. The traffic volume carried by the world's scheduled airlines has trebled during the past decade: the number of passengers transported rose from 31 million in 1950 to 108 million in 1960, the number of freight tonne-kilometres rose from 770 to 2,180 million and mail tonne-kilometres from 200 to 600 million. What will happen during the next decade passes conjecture.

What is more, a ticket for a trans-Atlantic flight costs 30 percent less today than it did ten years ago, and the IATA traffic conferences of 1960 resulted in the introduction of further drastic fare cuts in most regions of the world.

Finally, it should be called to mind that the IATA companies' fleets have increased from 2,000 aircraft to 3,500 in the past ten years, and that 400 jet aircraft are already in service, with over 400 more on order.

If we consider the capital invested in this fleet—the airlines will have to find more than $4,000 million by 1963—it is understandable that IATA has recommended a certain prudence, "to avoid the economic chaos which would result in the aviation industry with the premature introduction of the commercial supersonic aircraft." Before the airlines contemplate a further renewal of their entire fleets, the present generation of jets must first be assimilated.

The present and also, it should be added, a second—the generation which provides the topic for this issue.

*

The turboprop aircraft has been intentionally disregarded, and attention devoted exclusively to the jet. The editors have refrained from comment on the reasons why air transport planners have neglected the turboprop, and would merely remark that it is no longer to be found in future development programmes.

What does the programme for the next ten years look like? And what remains to be done?

In the article which follows, it is learnt that engine builders have successfully endeavoured to render jet transport not faster, but safer and more economical by developing the turbofan engine. Nor have airframe designers remained idle. Although aircraft are coming to resemble each other more and more closely in their basic configurations, a phenomenon which leads us to assume that they have reached a certain degree of maturity, the present issue shows interesting variants as regards engine layout.

There is no doubt at all that manufacturers are doing all they can to assist the airlines in the introduction of the new types. Their contributions in the form of easy payment facilities, training, technical literature etc., represent a great improvement over earlier service to customers. The airlines are not only most responsive to such assistance from the aircraft industry; they make the purchase of new aircraft to a great extent dependent on the cooperation of the supplier in preparing them for jet operations.

*

Although the present issue is devoted to new aircraft and their operation and not to the difficulties of ground organization, the two can hardly be kept separate. At first it seemed that the introduction of jets would lighten the burden on air traffic control, as the airspace available would so to speak be doubled, with the propeller-driven aircraft beneath and the jets above. If, however, most of the traffic shifts to the upper airspace, this will become increasingly congested.

High-altitude flights are not always made in perpetual sunshine, as the expression "flying over the weather" would lead us to believe; highly unpleasant meteorological phenomena can occur in the stratosphere, as the reader will learn from a report by a flight captain. Another article deals with long-range cruise procedures.

A report on the retailoring of Frankfurt Airport to face the jet age presents a typical example of how airports are preparing to receive jet aircraft.

There is one last problem, which mainly concerns the establishment of flight plans, but which is also of vital importance to air traffic control. Endeavours must be made to space out arrival and departure times on the world's main air routes so as to avoid congestion as far as possible. Even with mixed propeller and jet aircraft operations, it is difficult enough to clear a number of aircraft more or less at the same time, as each airline naturally wants to offer its passengers the most attractive arrival and departure times, and this tends to cause congestion at peak travel periods.

If, two or three years ago, four DC-6Bs or *Super Constellations* departed at the same time, the airport could just cope, although even then a swarm of 200 to 300 passengers would be streaming through the terminal building. But four fully-occupied 707s or DC-8s taking off or landing at the same time mean that 500 or 600 people all want to be cleared at "jet tempo." Customs officers, airport police, passenger handling and freight staff are, after all only human. At any rate, there is so far no evidence that they have secretly sprouted wings.

What is to be done? Planners must rationalize flight plans while there is still time. If they leave things too late, the terminal buildings will be crammed to overflowing, and the aircraft circling above the airport will be in grave danger. ←

The Decade Ahead

After Howard Hughes, major shareholder in TWA, had managed to help his company out of a financial predicament at the beginning of December, 1960, and to procure a bank loan for the payment of the jet fleet which TWA had ordered, the Finance and Transport Ministers of Denmark, Norway and Sweden met in Stockholm in mid-December to discuss the financial worries of SAS—worries to the tune of some 800 million Swedish crowns ($155 million), three quarters of which had gone to purchase 30 jet airliners, the remainder in the form of indirect expenses for the conversion of the ground organization to jet operations.

These are but two typical examples of the state of affairs in world air transport as a whole. "Although the trunk revenues were the highest ever," says the annual report of the Air Transport Association of America, "and represented a 9 percent increase over 1959, expenses went up at a higher rate: 14 percent. Chief among the reasons for the increase of costs were depreciation of new turbine-powered aircraft, and training and other introductory costs incurred in the transition to jet aircraft."

In other words, the airlines are not finding it easy to meet the obligations which they have been incurring since 1956 in the interests of modernization—obligations which, as ICAO predicted in 1958, would cause the airlines and the authorities responsible for ground organization many sleepless nights.

But despite all the difficulties facing air transport, the aircraft industry is today preparing the second generation of subsonic aircraft for long- and medium-haul operations, and has begun work on a completely new category, the short-haul jet airliner. And the design offices are already littered with projects for supersonic aircraft which are to be sold in ten years' time.

The aircraft industry draws its confidence from the knowledge that it will always find purchasers for new, high-performance aircraft, because the airlines cannot afford to let slip the opportunity to improve their services—and hence reduce operating costs and increase earnings.

The industry and the airlines plan together...

The jet aircraft sales campaign is by no means concluded. Every week manufacturers receive new orders, so that the airlines, according to a recent estimate by IATA Financial Director H. J. Gorecki, will have 700 jet aircraft by the end of 1963—a figure which will be further increased by orders for second-generation types.

The development and procurement of new aircraft does not, however, depend solely on the whims of producers and purchasers. Neither has a completely free choice; each must recognize the principles of air transport development and aim at putting successful types on the runway. That the aircraft industry and the airlines work side by side is in itself nothing new. One has only to think of the close collaboration between TWA Vice-President Jack Frye and Donald W. Douglas, which led to the construction of the DC-3 in the early thirties, or the no less fruitful cooperation between KLM President Albert Plesman and Anthony Fokker, which was decisive for the development of the aircraft industry and air transport in the Netherlands.

During World War II, these contacts between the industry and the airlines were severed. Designers were obliged to concentrate exclusively on military requirements, and logically enough, the airliners which appeared on the market after the war were derived from military transports and even from bombers, and had to find their feet in civilian life as best they could.

But shortly afterwards the manufacturers reorganized themselves and developed numbers of successful piston-engine types which brought air travel over the oceans and continents within the realms of the commonplace. With aircraft purchase prices of several million dollars, and the vast capacities of modern jet airliners, cooperation between the industry and the airlines has become even closer.

Changes have, on the other hand, been made in planning methods. For every new jet aircraft programme, roughly a hundred designs are examined, dozens of projects are dissected down to the smallest detail, models are tested for thousands of hours in wind tunnels, all imaginable route networks are closely scrutinized and the airline's operating costs and estimated profits calculated down to the *n*th decimal point. In other words, the aircraft manufacturer carries out a considerable portion of the airline's operational planning as "free publicity" and as a rule does not begin building the aircraft until it is already sold on paper. This is understandable when the high development costs are taken into consideration: $16 million for construction of the Boeing 707 prototype, $8 million for flight testing prior to delivery of the aircraft, $7 million for tests necessary to further development.

...but forecasting traffic volume is a matter of luck

Among the major problems during the project stage are the questions of whether the construction of the new aircraft is justified by future traffic expectations, and in what quantity it is to be produced. The latter question is particularly important, since the number of aircraft which must be produced to cover development costs is continually on the increase. For one of the latest medium-range models, the lowest number of aircraft which can be produced economically is 200.

In scheduled service for the past 10 months: A Pan American World Airways Douglas DC-8

Sir Aubrey Burke (left), Managing Director of Airco, and Anthony Milward, Chief Executive of British European Airways, on August 12th, 1959 signed a contract for the supply of 24 de Havilland DH.121 short- to medium-range jet airliners to a total value of £28 million.

Forecasters of future world traffic volumes seldom hit the mark. The purely arithmetical method of extrapolating past volume curves is unreliable because it is insufficiently flexible and takes no account of any of the factors which might affect the smooth course of the curve.

In 1955 and 1956, for example, no one would have been able to foresee that a short-lived economic recession in the USA in 1958 would lead to a pronounced slackening in the increase in passenger volume. Although the number of passengers had risen by a steady 10 to 15 percent since the end of World War II, the year 1958 brought an increase of only 1 percent. Nor could anyone at that time have foretold the enthusiasm with which travellers were to hail the jets in 1959, an enthusiasm which ensured that they were kept well filled.

To give an example of traffic volume forecasting in the jet age, in an ICAO study on the estimated effects of jet transport*, published in 1958, there is a comparative graph giving forecasts prepared by Boeing, Canadair and Douglas. While passenger-kilometre estimates are more or less the same until 1960, the forecasts for later years are so widely divergent that Boeing estimates 304,000 million passenger-kilometres against Douglas's 140,000 million.

In five years' time the world will see who was right.

Forecasts of traffic volume over given routes with given aircraft types are even less reliable than world-wide estimates. Let us take, for example, an analysis for a service A-B, which is based on the large tourist volume so far obtained for the region. Country B may unforeseeably stop the flow of tourists as a political measure, or the region may lose its attraction as a holiday area for other reasons; this will make a mockery of even the most scientific estimates. On the other hand, certain of the trends which serve as a basis for estimates—growth of population, urbanization, increase in national income etc.—can be predicted accurately enough on a long-term basis.

* "The Economic Implications of the Introduction into Service of Long-Range Jet Aircraft"; ICAO Document 7894 — C/907; page 20.

Hundreds more jets for long and medium haul

After the airframe manufacturer has racked his brains over the expected traffic volume, he must ask himself what the new type must be like in order to satisfy requirements: size, weight, flight and transport performance, together with initial and operating costs, play a vital role.

With regard to the size, all-up weight and transport capacity of the long-haul aircraft, the decisive step was taken with the transition from the piston-engine aircraft to the jet (from the 60 to 65 tons all-up weight of the *Super Constellation* and DC-7C to the 125 to 145 tons of the DC-8 and 707). This means that the second generation of long-range jets is unlikely to offer improvements which will revolutionize operations from top to bottom; developments will more probably be of an organic nature, e.g., increased range thanks to lower fuel consumption, shorter take-off distances, and reduced engine noise.

The main effort will be directed towards perfecting the long-range aircraft, as the advantages of jet transport are most evident for ranges of over 1,500 miles. Boeing estimates that long-range traffic volume will be quintupled during the decade 1960 to 1970. Next in importance will be medium-haul transport and the provision of new medium-range aircraft. It is generally agreed that there is no immediate urgency for the renewal of the typical short-haul aircraft; the untapped passenger reserves in this category must not, however, be allowed to remain so for long since, as ICAO statistics show, the average journey length per passenger is 640 miles.

The fast short-haul aircraft would be still more attractive if turnaround times could be further reduced to make it more effectively competitive with surface means of transport. Short-haul flights, whose main importance has been in the form of feeder services for transoceanic and transcontinental routes, could then become an independent means of transport, highly lucrative to its operators. Hence the general interest in V/STOL designs.

As for speed, it is undoubtedly the most tempting ware which the air transport industry has to offer. Moreover, it helps to determine the daily utilization of the aircraft over a given network and hence the profitability of air transport in general. In this respect, however, few, if any, striking innovations are to be expected of the aircraft industry within the coming five to ten years. All of today's jet airliners operate at the upper end of the subsonic range, and development has arrived at a natural threshold which can only be crossed economically when air transport can make the transition to speeds of Mach 2 or 3. As, however, about a decade will pass before such aircraft can be ready, a certain "pause for reflection" appears to lie ahead, a pause which can be used for perfecting types already in service and improving their economy of operation.

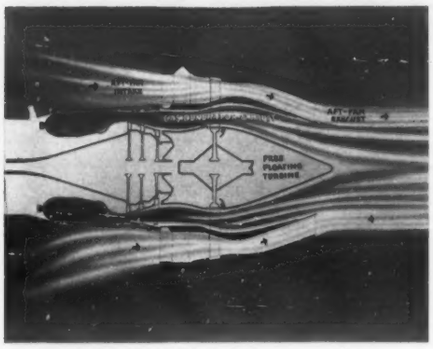
The turbofan shows the way

Even today, the direct operating costs of long-range jet transport are on an average less than 1.5 cents per seat-mile. Because of their alarmingly narrow margins of profit, however, airlines cannot contemplate further reductions in fares until technical advances have given them the means to do so. Engine manufacturers have recently found a solution to the problem in the turbofan engine, which promises enormous advantages during the next five to ten years.

Quite apart from the fact that it reduces fuel costs, this new form of engine is so far the most promising step towards rendering jet transport more profitable. The turbofan has two advantages: firstly, its lower specific fuel consumption enables payload to be increased or range to be lengthened with the same payload; secondly, its higher thrust-to-weight ratio improves take-off performance, enabling take-off distance to be reduced for the same take-off weight, or take-off weight to be increased for the same take-off distance. Finally, to the relief of passengers and those residing near airports, noise will be appreciably reduced.

It is however, regrettable that the fan engine has appeared on the scene two years after the beginning of jet operations. Companies wishing to benefit from this innovation are obliged to send the aircraft which they have already purchased back to the factory for a "rejuvenation treatment." Nevertheless, the turbofan engine will determine development trends in coming years: aircraft will not be faster, but they will be more efficient, safer and cheaper.

Typical representative of a new generation of jets: Powered by three Pratt & Whitney JT8D turbofan engines, the Boeing 727 will be delivered to United Air Lines from the end of 1963 onwards.



Turbofan engines are opening up new vistas for air transport, thanks to their economy of operation. *Left*, the Pratt & Whitney JT3D-1 engine with front fan, the powerplant for an American Airlines Boeing 707-120B. *Right*, a sectioned drawing of the aft-fan installation of the General Electric CJ-805-23.

The pros and cons of a new configuration

Airframe designers, too, have been seeking new ways of making tomorrow's aircraft more attractive. Exploiting the compact size and small diameter of the jet engine, which enable it to be installed almost anywhere on the aircraft, they have simply shifted the jets to the fuselage rear. This layout promises to give highly satisfactory results as regards both take-off and landing characteristics and economy during cruise. Although the layout chosen by Boeing Airplane Company, in which the engines are suspended from the wings, has proved to be a highly satisfactory solution, the results of intensive studies by Lockheed and Sud Aviation many years ago favoured the installation of the engines at the fuselage rear. And once the twin-jet Sud Aviation *Caravelle* had convincingly demonstrated the feasibility of this concept, the ice was well and truly broken.

Although repeated objections to this layout have been made on the grounds of increased empty weight, this disadvantage is more than offset by the higher lift of the clean wing, both during take-off and landing and during cruise. The aerodynamic advantages of the clean wing are self-evident; the leading edge slats and landing flaps can extend uninterrupted over the wing, and airflow interference between wing, engine nacelles and pylon mounts is eliminated. Although the lack of engine masses distributed across the wing span involves the construction of a more rigid and heavier wing, as the twist on the wing structure during high-speed flight is not counterbalanced by the weight of the engines, the rigid wing is nevertheless more robust and costs less to maintain than a highly elastic wing with engine pods.

On touchdown and in turbulent air conditions, the rear-mounted engines exercise considerable shear forces on the fuselage rear; this means that the fuselage must be reinforced, and the likelihood of fatigue cracks developing in the pressure cabin is thus reduced. Moreover, rear-mounted engines must be so rigidly mounted that they do not become detached in the event of a crash landing or ditching and pierce the wing roots which are filled with fuel. Here the reinforcement of the fuselage rear has a beneficial effect, as it provides the extra structural support for the high horizontal tailplane. A high T-tail is also desirable to keep the horizontal tailplane as far as possible from the jet efflux of the engines at the fuselage rear.

Although it is structurally not the simplest solution, the T-tail has certain aerodynamic advantages, which may be briefly summarized as follows. The downwash generated by the aircraft has a disturbing effect on the horizontal tailplane, which lies in its path. The higher the horizontal tailplane with respect to the wing, the less it is affected by the downwash and the greater will be its stability. In slow flight with a high angle of incidence, swept-wing aircraft with low horizontal tailplanes are subject to powerful tail-load moments, which are virtually absent in the case of aircraft with high horizontal tailplanes. In addition, the horizontal tailplane acts as it were as an end-plate for the vertical fin; this considerably increases its effectiveness where thrust is asymmetrical owing to engine failure.

An important advantage of the rear layout is that the asymmetrical thrust caused by the failure of one engine can be kept within reasonable bounds. As the noise cone of the engines installed at the tail does not touch the sides of the fuselage, vibration damage to the latter and to the upper surface of the tail is almost eliminated.

As for safety in the event of a crash landing, the danger of fire is considerably less in the case of rear-mounted engines. Furthermore, if turbines and compressor blades break in flight, no passengers are seated level with the engines. Finally, with the rear layout, an aircraft is far better equipped for ditching.

Any thrust reverser will of necessity raise dust and small pebbles from the ground, and these can cause damage to the compressor if sucked in by the engine. This danger is lessened if the engines are high above the ground, a fact which also speaks in favour of the rear-mounted engine.

Maintenance work is, however, considerably complicated by the height of the engines above the ground. What is more, the shifting of the aircraft centre of gravity rearwards, as is inevitable with rear-mounted engines, has certain disadvantages. As the useful load is increased, the centre of gravity shifts more than in an aircraft with wing-mounted engines—usually forwards—so that it will be necessary to control a wider range of centre of gravity changes. It remains to be seen whether airline engineers will welcome or regret this circumstance.

Pause for breath

So much for technical possibilities. As this brief survey has shown, engine and airframe manufacturers are in no way condemned to inactivity, even if the advent of the supersonic airliner is delayed for another decade. They have still much to do to get the best out of the subsonic airliner, both technically and economically. And while the industry devotes its efforts to maturing subsonic types, the airlines will have the opportunity to prepare the financial resources which will be indispensable if they are to re-equip themselves with supersonic aircraft. ←→

Manufacture of the Boeing 707 long-range jet airliner at Boeing Airplane Company's Renton plant. By the end of 1960 Boeing had supplied the airlines of the world with a total of 175 aircraft of the 707 and 720 models.

Jets of Tomorrow

The development of a modern jet aircraft takes five years from the beginning of design work until delivery of the first production aircraft, and three and a half to four years normally elapse between receipt of the first order for a new type and the time when it is placed in service. Small wonder, then, that the jets in scheduled service today, which were designed in the early fifties, have not had the benefit of the experience which the airlines have gained during the past two years. It is also understandable that airframe and engine manufacturers have improved upon their original projects wherever possible and have also designed completely new types to succeed the first generation of long-range jet aircraft. What is surprising is that the jets have conquered completely new markets in so short a time, markets which only a few years ago seemed to be the exclusive province of propeller-driven aircraft even in time to come. Not only did the jets take over intercontinental and transcontinental traffic; they also captured the medium-range market between the main centres of five continents and should, in the foreseeable future, have a share in short-range inter-city operations.

The jet aircraft demanded by the airlines and offered by the manufacturers can therefore now be divided into four distinct categories:

1 – long-range aircraft for intercontinental services over distances of more than 3,500 nautical miles;
2 – long- to medium-range aircraft for transcontinental operations and services between the main centres of individual continents, over distances of up to 3,500 nautical miles;
3 – medium- to short-range aircraft for services between industrial centres, over distances of up to 1,800 nautical miles;
4 – short-range aircraft for routes of lower traffic density and feeder services to large junction points; range approximately 500 to 1,000 nautical miles.

As the accompanying tables show, category 1 comprises aircraft with maximum take-off weights of roughly 135 to 155 tons (except the *Comet 4*), which can carry payloads of up to 25 tons on intercontinental routes. The aircraft of category 2 weigh between 70 and 120 tons and can carry 10 to 20 ton payloads over distances of up to 3,500 nautical miles. A number of them are derived from the long-range models of category 1 and have almost the same seating capacity as their larger predecessors. The aircraft in category 3 are designed specially for ranges of up to roughly 1,800 nautical miles (in exceptional cases even more than this), and with their take-off weights of 50 to 75 tons are considerably smaller than those of categories 1 and 2; they can transport payloads of 8 to 10 tons. Finally, in category 4, only three projects have so far been announced, which may possibly not be typical of later developments. Even now, however, it is clear that the very short-range jets will operate at relatively high subsonic cruising speeds and carry payloads of 5 tons over distances of up to 1,000 nautical miles; they will probably fall within the 20 to 25 ton weight class and will presumably have two jet engines.

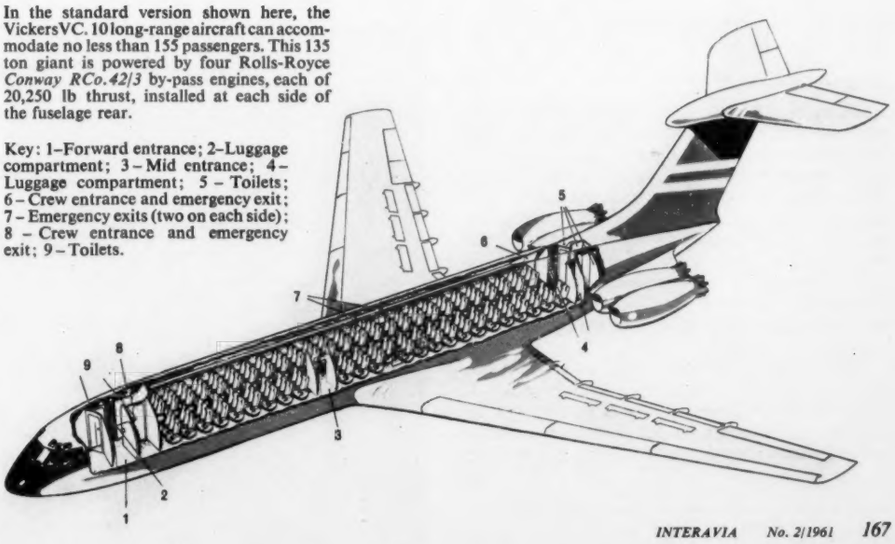
As is shown by the accompanying box with details of jet aircraft on order by the world's air-

AIRLINE JET TRANSPORT ORDERS and DELIVERIES
(As at mid-January 1961)

Type	Total Firm Order	Airline ordering (deliveries)	Total in service
LONG RANGE (Intercontinental)			
BOEING 707-320/420	100	Air India 6 (3). Air France 21 (17). BOAC 15 (15). El Al 3. Ghana 2. Lufthansa 5 (4). Pan Am 26 (23). Sabena 5 (5). SAA 3 (3). TWA 12 (12). Varig 2 (2).	84
DOUGLAS DC-8 series 30	57	JAL 5 (4). KLM 7 (7). Northwest 5 (5). Pan Am 19 (17). Panagra 4 (4). Panair 2. SAS 7 (7). Swissair 3 (3). TAI 3 (1). UAT 2 (2).	50
series 40	23	Alitalia 8 (4). CPAL 4. TCA 11 (7).	11
series 50	14	Iberia 3. KLM 6. PAL 2. UAL 3.	
de HAVILLAND *Comet 4*	27	Aerolíneas Argentinas 6 (6). BOAC 19 (19). EAA 2 (2).	27
VICKERS-ARMSTRONGS VC.10	35	BOAC 35.	—
Super VC.10	10	BOAC 10.	—
TOTAL	266	TOTAL	172
LONG-MEDIUM RANGE (Continental)			
BOEING 707-120/220	69	American 26 (25). Braniff 5 (4). Continental 5 (5). Pan Am 6 (6). Qantas 10 (7). TWA 15 (15). Western (2 leased from Boeing).	64
BOEING 720/720B	91	American 25 (10). Avianca 2. Braniff 3. Eastern 15. Ethiopian 2. Irish 3 (1). Lufthansa 8. UAL 29 (13). Western 4.	24
CONVAIR 880	43	Delta 13 (10). Northeast 6 (4). TWA 24 (6).	20
880M	13	Avensa 1. Alaska 1. CAT 1. JAL 3. Unannounced 7.	
990	37	American 25. REAL 3. SAS 2. Swissair 7.	
DOUGLAS DC-8 series 10/20	63	Aeronaves de México 1. Delta 6 (6). EAL 16 (11). National 3 (3). UAL 37 (32).	52
de HAVILLAND *Comet 4B*	18	BEA 14 (7). Olympic 4 (4).	11
Comet 4C	12	CMA 3 (3). MEA 4 (1). UAA-Misrair 5 (2).	6
TOTAL	346	TOTAL	177
MEDIUM-SHORT RANGE			
BOEING 727	80	EAL 40. UAL 40.	—
de HAVILLAND DH.121 *Trident*	24	BEA 24.	—
SUD-AVIATION *Caravelle I / IA / III*	69	Air France 35 (24). Air Algérie 4 (4). Alitalia 4 (4). Finnair 4 (3). Royal Air Maroc 2 (1). SAS 14 (14). Swissair 4 (4). Varig 2 (2).	
Caravelle VI	36	Air Algérie 2. Alitalia 4. Iberia 4. Sabena 6. UAL 20.	56
VICKERS-ARMSTRONGS VC.11	—		—
TOTAL	209	TOTAL	56
OVERALL TOTAL	821	OVERALL TOTAL	405

In the standard version shown here, the Vickers VC.10 long-range aircraft can accommodate no less than 155 passengers. This 135 ton giant is powered by four Rolls-Royce *Conway RCo.42/3* by-pass engines, each of 20,250 lb thrust, installed at each side of the fuselage rear.

Key: 1–Forward entrance; 2–Luggage compartment; 3 – Mid entrance; 4 – Luggage compartment; 5 – Toilets; 6 – Crew entrance and emergency exit; 7 – Emergency exits (two on each side); 8 – Crew entrance and emergency exit; 9 – Toilets.

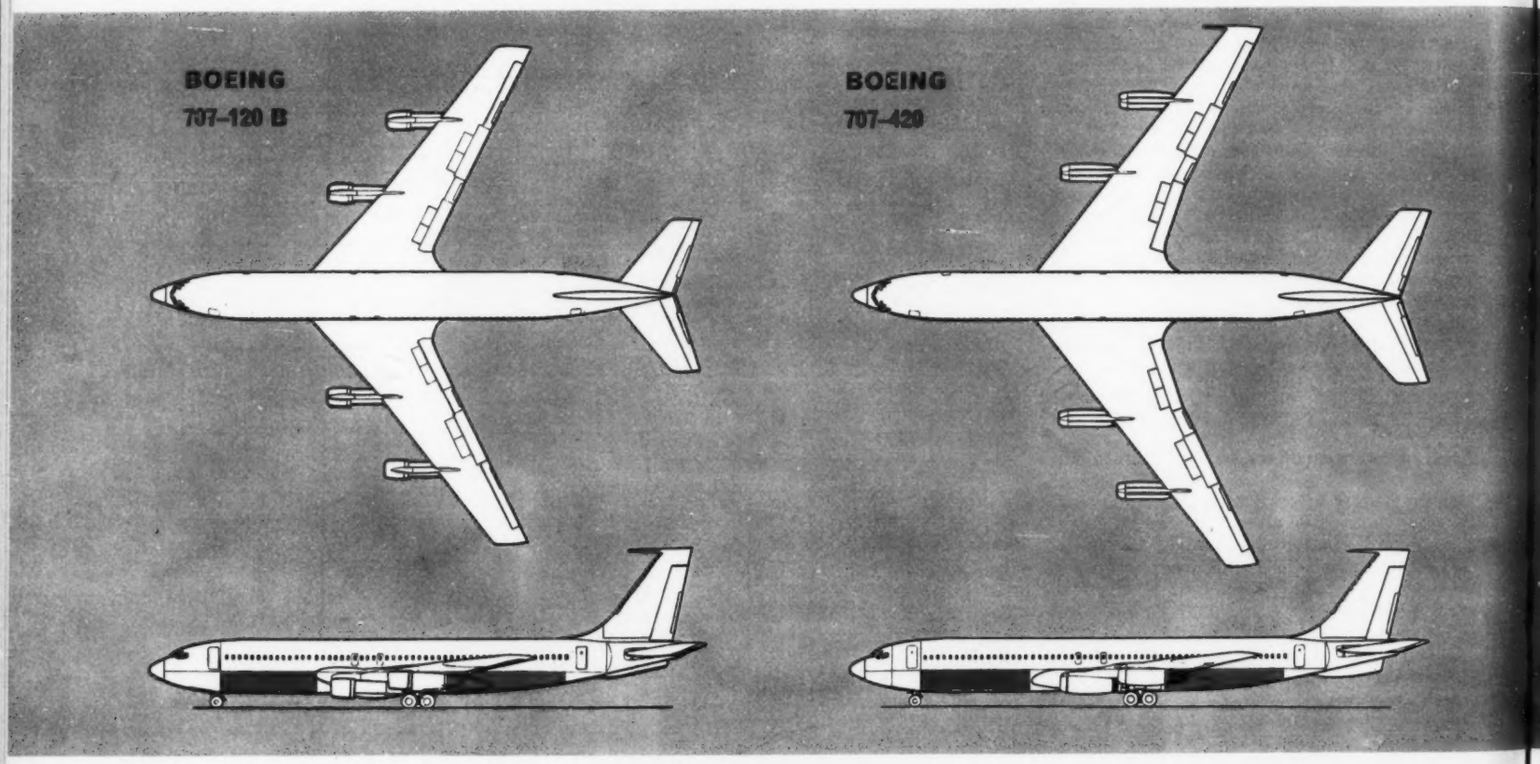


lines (with the exception of the Eastern bloc), a total of 821 jet airliners had been ordered by the time these lines went to print; only 405 of these have, however, so far been delivered. As this order-book comprises only deliveries up to 1963, it is not hard to imagine that the combined fleets of the world's airlines will number well over 1,000 by the time the first supersonic types enter scheduled service at the beginning of the seventies.

From the number of aircraft in the first three categories already delivered, it will be seen that the airlines have first procured long-range aircraft, then a considerable number of long- to medium-range types, and finally—doubtless influenced by the success of the Sud Aviation *Caravelle*—have proceeded to order over 200 typical medium-range aircraft. Jet transport is thus continually broadening its horizons and will soon penetrate all markets with the purchase of the first twin-jet short-range aircraft; investments

A Swissair Douglas DC-8.

Scale of two-view drawing 1:500. The shaded areas in the lower pictures are freight holds.



Boeing 707 *Intercontinental*.

in the near future are expected to be increasingly concentrated on medium- to short-range aircraft.

Long-range aircraft

When, in October, 1955, Boeing and Douglas announced the first substantial orders for their long-range aircraft and published details of these types, the similarity between the two firms' designs was striking. For over ten years, the USAF's jet bombers have had swept wings with the engines in pods underneath—a configuration which retained its validity for the representatives of the first generation of civil jets and has been continued even in later long- and medium-range models such as the Boeing 720, the Convair 880 and the Convair 990.

The French firm of Sud Aviation had, however, been investigating the rear-mounted engine layout since the early fifties, and successfully put its theories into practice in the *Caravelle* medium-range aircraft. Thereupon, the designers of long-

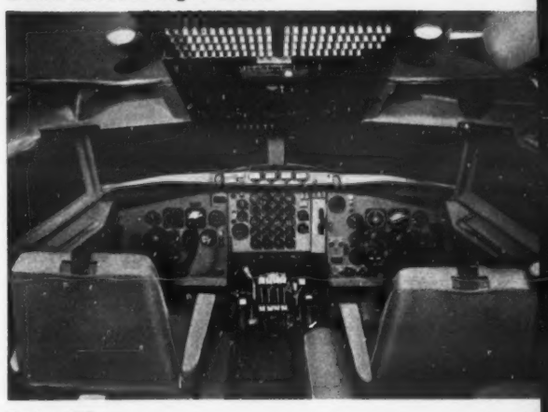
range aircraft began to consider whether and how this formula could be used for large transports weighing over 135 tons. Vickers-Armstrongs (Aircraft) Ltd., which had lagged somewhat behind after the first vast jet orders had already gone to Boeing and Douglas, unreservedly adopted the rear engine layout and created an interesting new generation of intercontinental aircraft with the VC.10 and its derivative, the Super VC.10. Another article in this issue deals with the advantages and disadvantages of the rear-mounted engine layout, and it remains to be seen what experience BOAC will gain from the 35 VC.10s which it has ordered from Vickers and will receive in 1963.

Vicker's main sales points—improved take-off and landing performance (particularly at high-altitude airports and in tropical regions), improved stability due to the high horizontal tailplane, and increased passenger comfort—are most convincing and could more than compensate for the relatively late appearance of the aircraft in scheduled service, as the VC.10 and its derivatives will fly for many years in competition with the big jets of Boeing and Douglas.

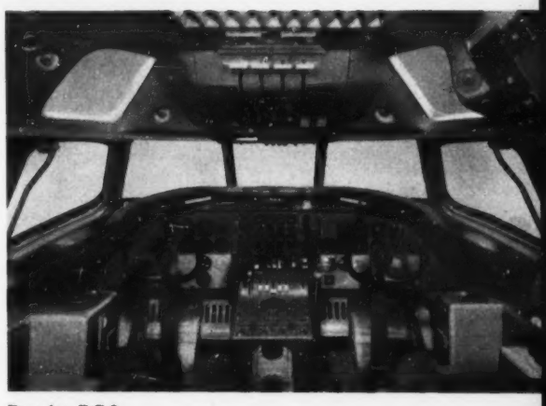
The configuration, engine layout and cabin of the VC.10 are shown in the sectioned drawing on the next page. The high lift coefficient of the wing is obtained by leading-edge slats and by landing flaps of large area, both extending over the full span of the wing from the fuselage to the ailerons. During high-altitude cruising, too, the aerodynamically clean wing gives promise of increased economy, and Vickers points out that the high tail greatly reduces the normally substantial airflow interference between horizontal tailplane and fin, as the maximum airfoil thicknesses of the two surfaces are sufficiently far apart.

As for passenger comfort, it should be emphasized that the jet efflux of the rear-mounted engines cannot cause vibration in the fuselage, and passengers are shielded from the high-frequency

Some modern flight decks



Boeing 707.



Douglas DC-8.

Vickers VC.10.

I - Long range jet transports

Manufacturer and type	Power plant and thrust	Span: length	Wing area sq. ft.	Max. Take-off weight / Landing weight lb	Max. payload lb	Fuel capacity Imp. gal.	Passenger capacity + and class	Max. cruising speed kts / cruising height ft	CAR Runway length Take-off ft / Landing ft	Range (n.m.) / payload lb	Remarks
Boeing 707-320	P & W* JT4A-9 4 × 16,800 lb	142 ft 5 in 152 ft 11 in	2,892	311,000 207,000	57,100	17,650	F 131 E 189	520 25,000	10,200 7,200	3,995 57,100	Intercontinental. Range without reserves
Boeing 707-420	RR* Conway RCo.12 4 × 18,000 lb	142 ft 5 in 152 ft 11 in	2,892	311,000 207,000	58,800	17,650	F 131 E 189	525 25,000	10,700 7,200	4,090 58,800	Intercontinental. Range without reserves
de Havilland Comet 4	RR Avon RA.29 4 × 10,500 lb	114 ft 9 in 111 ft 6 in	2,121	162,000 120,000	20,300	8,898	F 60 E 81	450 28,500	6,750 6,630	3,640 20,300	Range without reserves
Douglas DC-8-30	P & W JT4A-3 4 × 15,800 lb	142 ft 5 in 150 ft 6 in	2,773	310,000 199,500	36,500	19,150	F 112 E 173	510 30,000	10,800 6,590	4,600 —	Maximum range
Douglas DC-8-40	RR Conway RCo.12 4 × 17,800 lb	142 ft 5 in 150 ft 6 in	2,773	310,000 199,500	36,500	19,150	F 112 E 173	515 30,000	9,750 6,590	4,715 —	Maximum range
Douglas DC-8-50	P & W JT3D-3 4 × 18,000 lb	142 ft 5 in 150 ft 6 in	2,773	310,000 199,500	36,500	19,150	F 112 E 173	510 30,000	9,750 6,590	5,150 —	Maximum range
Vickers VC.10	RR Conway RCo.42 4 × 20,250 lb	140 ft 158 ft 10 in	2,800	299,000 197,500	38,000	17,250	F 88 E 155	520 35,000	7,400 6,400	4,800 38,000	Range without reserves
Vickers Super VC.10	RR Conway RCo.42/2 4 × 21,825 lb	146 ft 186 ft	2,800	347,000 241,000	58,000	18,750	E 212	500+		3,500 58,000	Range without reserves

* P & W = Pratt & Whitney; RR = Rolls Royce; + F = First Class; E = Economy Class

air intake noises by special insulation devices in the fuselage rear. However, the successful suppression of engine noise in the cabin means that noise from other sources, such as the air conditioning system and its blower, must likewise be reduced. If such sounds were inaudible in "noisy" jets, they are a considerable source of nuisance in an aircraft where engine noise cannot be heard inside the cabin.

The freight and baggage holds under the cabin floor and their hatches are of such generous dimensions that loading and unloading times will be cut to a minimum. Although the maintenance of the four Rolls-Royce *Conway RCo.42* by-pass engines requires the provision of special high-level platforms, the installation of the engines in two groups at the sides of the fuselage has certain advantages.

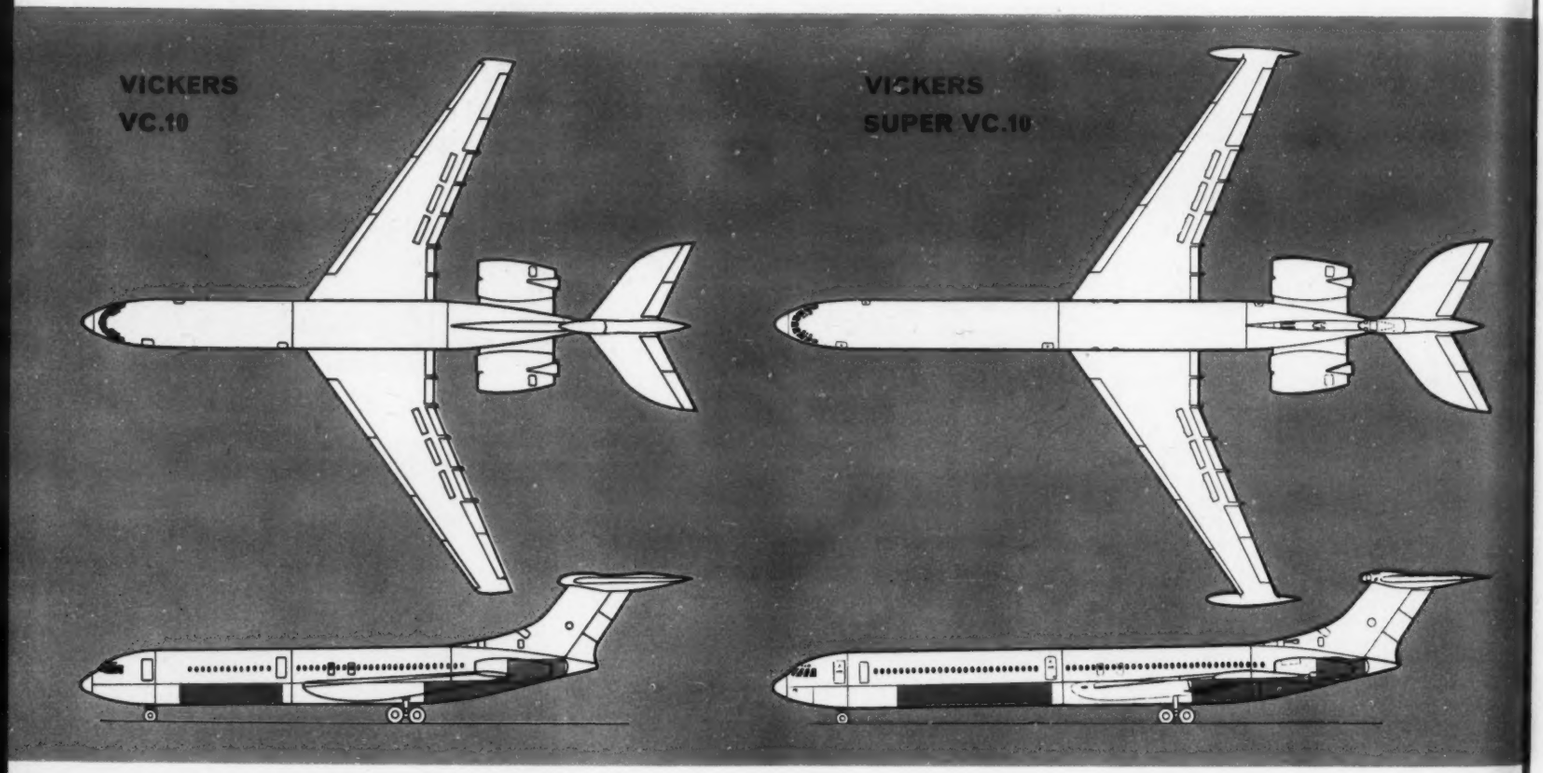
In Vickers' Weybridge and Hurn plants the first VC.10s for BOAC are under construction; no prototype has been built. The first production aircraft will be thoroughly tested by the manufacturers in all phases of flight, early in 1962, so that any minor modifications can be made before deliveries begin in 1963.

In the meantime, the Super VC.10 is taking shape, and will be placed in service on BOAC's North Atlantic routes from 1965 onwards. Along with the Soviet Tupolev Tu-114, the Super VC.10 will be the largest airliner in the world. The fuselage, which will be 27 ft longer than that of the normal VC.10, will be able to accommodate up to 212 passengers. As if this were not enough, in autumn last year Vickers announced plans for a "Super Super VC.10," which would weigh 165 tons and carry 222 passengers. The standard version of the VC.10 without spares, will cost about £2.1 million, and the price of BOAC's Super VC.10 will run to about £2.5 million.

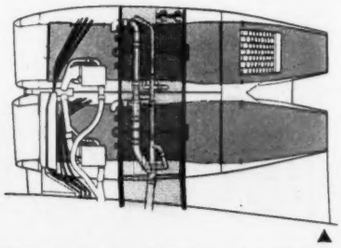
Meanwhile, Boeing and Douglas have not been idle, but have been modernizing the Boeing 707/320 and 420 and the Douglas DC-8 *Intercontinental* long-range aircraft, developed some years ago. Douglas, like Boeing, has embarked on a comprehensive programme to increase the range, speed and payload of its aircraft. Among the modifications envisaged are a sharper wing leading edge which will on the one hand increase the wing chord and reduce the thickness/chord ratio, and on the other increase the wing area. These modifications will be incorporated on the production line from aircraft No. 148 onwards. All Series 50 DC-8s are fitted with Pratt & Whitney JT3D turbofan engines, which substantially improve performance.

A separate article deals with Boeing's programme for improving the 707. Improvements to the long-range version include a ventral fin under the fuselage rear and a lengthened tail fin.

There are rumours that Boeing is working on an enlarged version of the 707 *Intercontinental*, but the company has so far refused to confirm this. In addition, it is considering a special version with a bar/lounge under the fuselage nose to while away the passengers' time in long-distance flights. In this variant the entire fuselage nose would be modified, the underside having a pronounced bulge down to the level of the wings.



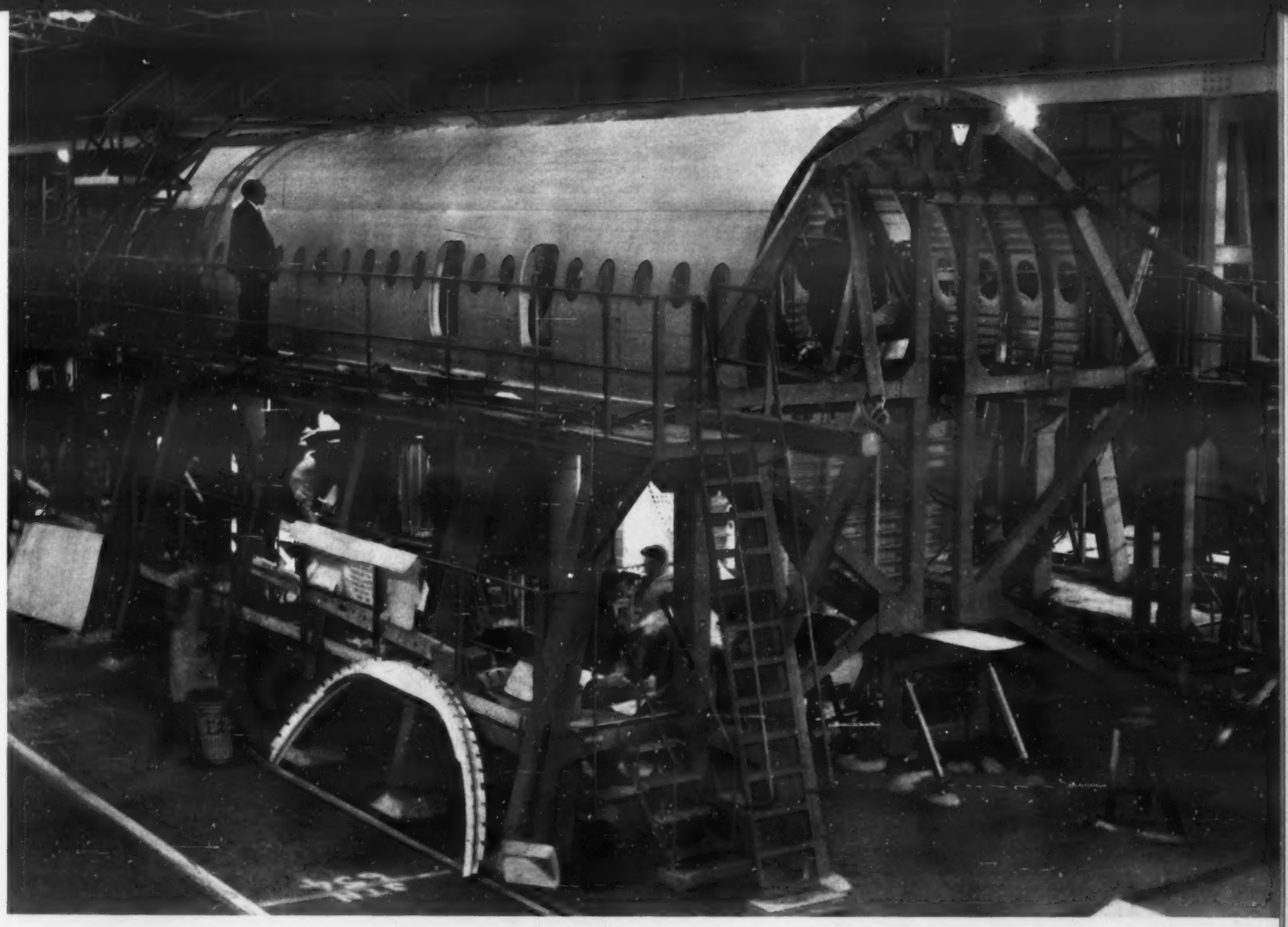
New trends in jet transport: model of the Vickers VC.10, at present under construction, with two engines on each side of the fuselage rear.



The two starboard engines of a Vickers VC.10. The hydraulic and electrical lines in front lead to the compressor housing, while those in the rear (area shaded in grey between engine mounts) are fuel feed lines.

Long- to medium-range aircraft

Although the 120 and 220 versions of the Boeing 707 and the Series 10 and 20 of the DC-8 were designed for medium- to long-range transcontinental services between major cities, Boeing and Convair have built other aircraft specially for this market. Boeing has brought out the 720, which is being produced at high pressure at Renton and has a number of advantages over the 707 on which it is based. The wing leading edge between the side of the fuselage and the inner engine pylon has been fitted with a glove to increase the wing chord and raise the critical Mach number from 0.88 to 0.90. To improve take-off and landing characteristics, the wing leading edge



The first VC.10 fuselages being built at Vickers-Armstrongs (Aircraft) Ltd.'s Weybridge facility. In the jig illustrated above, the pre-assembled upper fuselage section, including cabin floor, is joined to the lower fuselage section and wing spar boxes. To speed production of the VC.10, Vickers uses double sets of special tools and jigs.

has been fitted with three auxiliary flaps on each side, which deflect forwards and downwards. The 720B version has Pratt & Whitney JT3D-1 turbofan engines which improve performance and economy of operation.

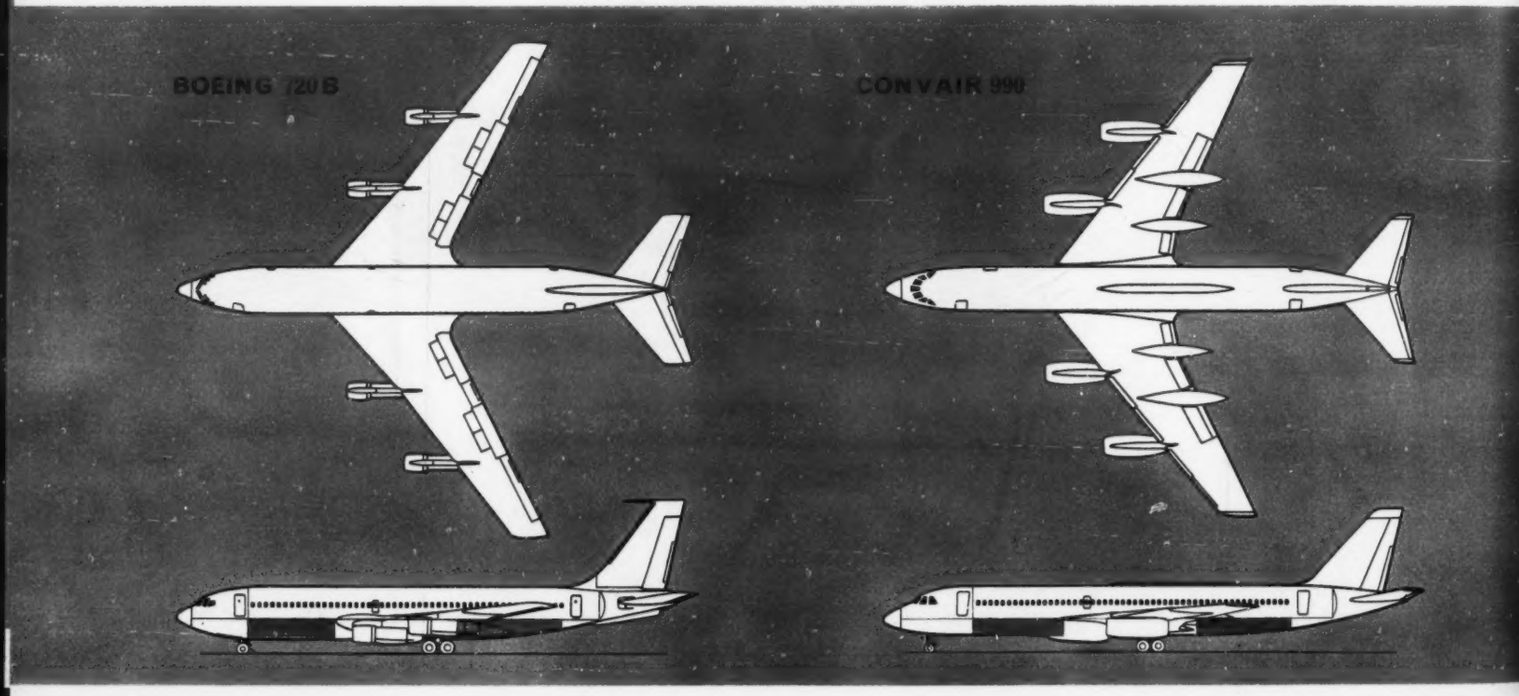
In summer, 1956, Convair embarked on the development and construction of the 880, which made its first flight on January 27th, 1959, over a year after the Boeing 707/120 had made its official flight tests for certification. Powered by four General Electric CJ-805-3s, the 880 was considered the fastest jet airliner until the appearance of its successor, the 990. The maximum cruise Mach number of the latter is no less than Mach 0.91, and a closer approach to the sound barrier is hardly justifiable economically.

In the intercontinental version ordered by Swissair and SAS, the Convair 990 has the impressive range of over 4,800 nautical miles (without fuel reserves and, of course, with reduced payload). A detailed description of the Convair 990 *Coronado* will be found in another article in this issue. The Convair 880, too, has undergone certain improvements—the fitting of leading edge flaps in four sections, power-assisted rudder, enlarged fin, structural alterations to the fuselage to accommodate additional fuel tanks, reinforced undercarriage etc.,—and will be offered with these modifications under the designation 880M.

Medium- to short-range aircraft

It is hardly surprising that after the substantial investments made to re-equip airline fleets for long- and medium/long-range operations, considerable sums should be spent on new medium/short-range aircraft of the 1,500 nautical mile range class. But the average distance travelled per passenger, calculated by IATA on a world-wide basis, is at present only 550 nautical miles. The fact that the airlines have ordered as many medium- to short-range aircraft as they have long-range types reflects the confidence with which they look forward to jet operations over shorter distances.

The pace-setter in this category was beyond all doubt the Sud Aviation *Caravelle*, which has matured impressively in recent years. In January, 1953, the then Sud-Est Aviation won the French Government design competition for a jet airliner



II - Long/medium range transports

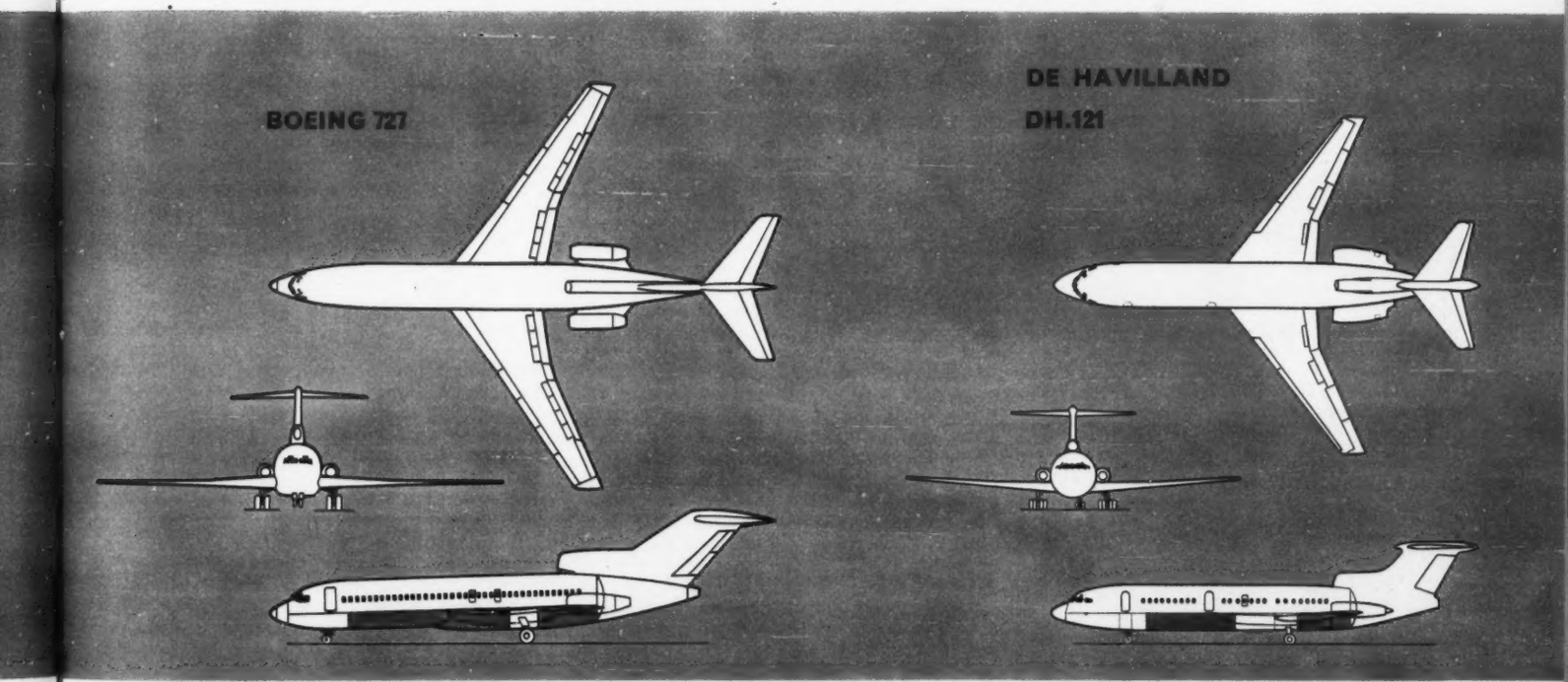
Manufacturer and type	Power plant and thrust	Span: length	Wing area sq. ft.	Max. Take-off weight / Landing weight lb	Max. payload lb	Fuel capacity Imp. gal.	Passenger capacity + and class	Max. cruising speed kts / cruising height ft	CAR Runway length Take-off ft / Landing ft	Range (n. m.) / payload lb	Remarks
Boeing 707-120B	P & W JT3D-1 4×17,000 lb	130 ft 10 in / 144 ft 6 in	2,433	258,000 / 185,000	53,000	11,220	F 121 E 179	525 / 25,000	8,600 / 5,980	3,570[1] / 53,000	Development of the 707-120 with by-pass engines. [1] Range without reserves
Boeing 707-220	P & W JT4A-3 4×15,800 lb	130 ft 10 in / 144 ft 6 in	2,433	247,000 / 175,000	48,750	11,220	F 121 E 179	525 / 25,000	6,700 / 6,350	3,250[2] / 48,750	[2] Range without reserves
Boeing 720	P & W JT3C-7 4×12,000 lb	130 ft / 136 ft 4 in	2,433	203,000 / 175,000	37,000	9,855	F 110 E 165	520 / 35,000	6,700 / 6,240	2,600[3] / 37,000	[3] Range without reserves. Boeing 720B with four Pratt & Whitney JT3D-1 of 17,000 lb thrust each. Maximum take-off weight 229,000 lb
Convair 880/22	GE* CJ-805-3 4×11,200 lb	120 ft / 129 ft 4 in	2,000	184,500 / 132,800	23,150	8,900	F 88 E 110	530 / 40,000	5,860 / 5,460	2,780 / 23,150	880/22M version with four General Electric CJ-805-3B of 11,650 lb thrust each
Convair 990 Coronado	GE CJ-805-23 4×16,100 lb	120 ft / 139 ft 5 in	2,250	244,000 / 180,000	27,890	13,050	E 121	550 / 35,000	5,350 / 4,770	3,730[4] / 25,120	[4] Maximum range Maximum Mach No. 0.91
de Havilland Comet 4B	RR Avon RA.29/1 4×10,500 lb	107 ft 10 in / 118 ft	2,059	158,000 / 120,000	24,600	7,800	F 72 E 102	460[5] / 23,500	6,600 / 6,660	2,920[6] / 24,600	[5] Max. economy cruise speed [6] Range without reserves
de Havilland Comet 4C	RR Avon RA.29/1 4×10,500 lb	114 ft 9 in / 118 ft	2,121	162,000 / 120,000	24,600	8,900	F 72 E 102	440[7] / 33,000	6,750 / 6,630	3,140[8] / 24,600	[7] Max. economy cruise speed [8] Range without reserves
Douglas DC-8-20	P & W JT4A-3 4×15,800 lb	142 ft 5 in / 150 ft 6 in	2,773	276,000 / 193,000	34,030	14,600	F 112 E 173	510 / 30,000	8,200 / 6,400	3,720[9]	[9] Maximum range

* GE = General Electric; + F = First Class; E = Economy Class

III - Medium/short range transports

Manufacturer and type	Power plant and thrust	Span: length	Wing area sq. ft.	Max. Take-off weight / Landing weight lb	Max. payload lb	Fuel capacity Imp. gal.	Passenger capacity + and class	Max. cruising speed kts / cruising height ft	CAR Runway length Take-off ft / Landing ft	Range (n. m.) / payload lb	Remarks
Boeing 727	P & W JT8D-1 3×14,000 lb	108 ft 134 ft 1 in	1,650	142,000 131,000	24,000	6,130	F 70 E 114	520 35,000	5,000	24,000[1]	Under Development [1] Range without reserves
British Aircr. Corp. DH.121 Mk.1	RR RB.163 3×10,100 lb	89 ft 10 in 114 ft 9 in	1,358	105,000 100,000	22,370	3,840	E 97	510 32,000	6,000 3,760	1,460[2] 22,370	Prototype in construction. [2] Range without reserves Mk.2 is a further development with increased range
Dresden Typ 152	Pi* 014-A1 4× 7,275 lb	88 ft 7 in 107 ft 1 in	1,485	112,440 88,185	20,110	4,200	F 58 E 73	470 32,810	6,890[3] 4,595	1,850	[3] Take-off and landing distances according to ICAO formula
Sud Aviation Caravelle III	RR Avon RA.29/3 2×11,400 lb	112 ft 6 in 105 ft	1,579	101,410	17,640	4,070	F 64 E 80	430	5,970[4] 5,020	1,165[5] 17,640	[4] Take-off distance at max. take-off weight. Landing distance at 83,780 lb. [5] Range with 6,500 lb reserves
Sud Aviation Caravelle VI R	RR Avon RA.29/6 2×12,600 lb	112 ft 6 in 105 ft	1,579	110,230	17,640	4,070	F 64 E 80	455	6,660[6] 4,810	1,440[7] 17,640	[6] Take-off distance at max. take-off weight. Landing distance at 88,625 lb. [7] Range with 7,010 lb reserves
Sud Aviation Caravelle VII	GE CJ-805-23C 2×16,100 lb	112 ft 6 in 108 ft 8 in	1,579	114,640 109,130	19,840	4,070	F 68 E 89	460 23,620	6,400[8] 6,020	1,850[9] 17,640	[8] Take-off distance at max. take-off weight. Landing distance at 91,710 lb. [9] Range with 7,495 lb reserves
Sud Aviation Caravelle X	P & W JT8D-1 2×14,000 lb	112 ft 6 in	1,579	113,540				450	6,660[10] 4,460	1,850[11] 17,640	[10] Take-off distance at max. take-off weight. Landing distance at 89,290 lb. [11] Range with 7,605 lb reserves
Tupolev Tu-104A	Mi* AM-3M 2×19,180 lb	113 ft 4 in 124 ft 10 in	2,024	165,350 141,100	29,760		F/E 16/54	510 29,529	5,410[12] 5,050	2,270[13] 17,640	[12] Take-off and landing distance over 50 ft screen [13] Range with reserves: Tu-104B fuselage is 117 ft 1 in. in length, 100 passengers
Tupolev Tu-124	So*by-pass 2× ?						F 44 E 68	470	4,920[14]	810[15]	[14] Take-off and landing distance over 50 ft screen [15] Range with reserves
Vickers VC.11	RR RB.163 4×10,100 lb	103 ft 136 ft		170,000 138,500			E 138			1,800[16]	[16] Range with max. payload

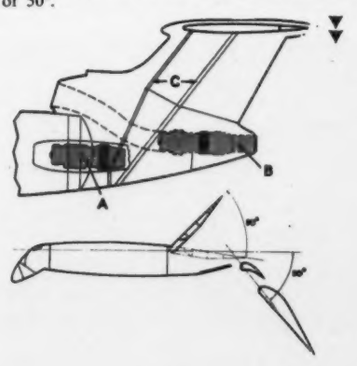
*P & W = Pratt & Whitney; GE = General Electric; RR = Rolls-Royce; Pi = Pirna; Mi = Mikulin; So = Soloviev + F = First Class; E = Economy Class



A Delta Airlines Convair 880 taking off on a record-breaking transcontinental flight from San Diego to Miami. The 2,338 mile flight was made at an average speed of 665 m.p.h.

Layout of the three engines at the rear of the DH. 121. Two engines (A) are mounted at the fuselage sides, the third (B) in the fuselage rear itself. (C) main spars of the vertical tailplane. ▼

Section through the airfoil of the de Havilland DH.121. The entire wing leading edge can be deflected downwards by 30°, the landing flap deflection is 50°, and the air brakes in the upper side of the wing open upwards at an angle of 50°.



of the 35 to 40 ton weight class. In the same year the company received a Government contract, and by May 27th, 1955, the *Caravelle* was taking off on its maiden flight. In February, 1956, Air France placed an initial order for twelve aircraft, and *Caravelle Is* have been in scheduled service since the spring of 1959. They were followed by the *Caravelle III* variant with more powerful *Avon* jets and higher all-up weight, then by the *Caravelle VI* and *VI R* with still more powerful jets and a take-off weight of 50 tons. Under an agreement between Sud Aviation and Douglas, the *Caravelle VII,* powered by General Electric CJ-805-23 turbofan engines, will be built by the American firm under licence. General Electric has bought a *Caravelle VII* for certification tests (and sales promotion), and this began flight tests in mid-January. Sud Aviation is now at work on the *Caravelle X* with Pratt & Whitney JT8D-1 turbofan engines built under licence by SNECMA, which will enable the all-up weight to be further raised to 51.5 tons, with a corresponding increase in payload and longer range. The United Air Lines order for 20 *Caravelle VIs*—the first purchase of jet aircraft from Europe for an American airline's domestic operations—can, like the

The VEB Flugzeugwerke Dresden Type 152 short- to medium-range four-jet airliner.

De Havilland D.H.121 short- to medium-range aircraft.

success of Sud Aviation's entire sales campaign (105 aircraft delivered or on order), be considered as conclusive proof of the rise of the medium-range aircraft.

In Britain, de Havilland and BEA noted this trend and as early as 1956 were collaborating in the development of a British medium-range jet airliner, but the project was held up for political and administrative reasons. De Havilland received a provisional order in 1958, but it was not until August, 1959 that BEA announced the order of 24 D.H.121 *Trident Mk.1s,* with delivery to begin in the summer of 1963. Although flight tests

The Tupolev Tu-124 for 44 passengers, the first Soviet airliner with by-pass engines.

are to begin at the end of this year, deliveries are not expected to be concluded until 1965.

Though Sud Aviation pioneered the rear-mounted engine layout, it was de Havilland which revived the three-engine layout, which had aroused interest decades ago, but had in the meantime lapsed into oblivion. The *Trident* has three rear-mounted engines, one at each side of the fuselage, the third inside the fuselage rear itself. The designers of the D.H.121 aimed at an aircraft with take-off distances of the order of 5,200 ft and the ability to transport 100 passengers on typical inland routes over distances of about 1,000 nautical miles. The aircraft would operate with optimum economy during take-off, climb and cruise; the manufacturers claim that such economy is only possible in an aircraft of the D.H.121's weight class if a three-engine layout is adopted. After Boeing had followed the British firm's example and developed a three-engine medium-range aircraft, de Havilland considered the possibility of developing a slightly larger version of the *Trident* with increased range, to meet competition from the Americans and from the British Vickers VC.11. The improved version bears the designation *Trident Mk.2.* It is not, however, yet known whether de Havilland will continue development.

Interavia reported on the new Boeing 727 medium-range aircraft in the January issue (p.29). Apart from the three engines at the rear, the aircraft's most significant feature appears to be the exceptional high lift coefficient of the wing. Wind tunnel tests have shown that this can reach a value of almost 2.8—without boundary layer control—so that with a gross weight of 64 tons the aircraft could operate from 5,000 ft runways. The fuselage is so spacious that up to 114 passengers can be seated in the economy class. As, according to Boeing's calculations, the direct operating costs over 500 mile stages amount to only $1.50 per mile, passenger-mile operating costs for a fully loaded aircraft in the typical 92 passenger mixed class version would run to about 1.6 cents per passenger mile, i.e., no more than the corresponding costs for turboprop aircraft. In the 114 passenger economy class version the seat-mile costs are actually less than those for a modern turboprop. The upper half of the fuselage (above the cabin floor) has the same cross-action as that of the Boeing 707 and 720, so that with six seats per row the degree of comfort is the same. The first Boeing 727s will be delivered to United Air Lines and Eastern Air Lines in 1964.

Vickers, too, has set its stakes on medium- and short-range transport and projected a smaller version of the VC.10 which, powered by four Rolls-Royce RB.163s, could cover distances of 1,500 nautical miles with 138 passengers and a substantial volume of freight. With a take-off weight of over 75 tons, the VC.11 would lie at the upper end of the aircraft category discussed in this section, so that medium-range transport, too, offers a large number of types to suit all range and weight requirements.

*

Development in the East is not following quite the same lines as that in the West. But here, too, designers seem to be concentrating on the development of new and economical medium-range types. Some years ago, in the German Democratic Republic, the Type 152, with four Pirna 014-Al jets, took shape in the design offices of VEB Flugzeugbau Dresden. In the Soviet Union, the Tu-124 medium-range aircraft was developed out of the Tu-104A and B; the new model, which is powered by Soloviev jets, is the first aircraft in scheduled service to have turbofan engines.

The more spacious seating layout of the Russian aircraft shows that neither Soviet aircraft manufacturers or operations planners are as concerned about profits as their Western colleagues. The standard version of the Tu-124, for instance, has only 44 seats, and even the tourist version has only 60, while comparable Western types must accommodate 80 to 90 passengers even in the mixed class configuration.

The Sud Aviation *Caravelle,* which is sold in the USA by Douglas Aircraft Company.

Short-range aircraft

Although market analyses have for some time revealed a continually increasing need for fast aircraft for typical short-haul services, the airlines have not been in any great hurry to introduce short-range jets. Piston-engine and turboprop aircraft, which were available in large numbers, seemed adequate for all requirements and promised to be cheaper in operation over short stage lengths. The situation has, however, changed with the advent of new by-pass engines with a high by-pass ratio, engines which have the advantage of a very low specific fuel consumption. It is now expected that the airlines will place orders for a first generation of short-range jet aircraft within the foreseeable future.

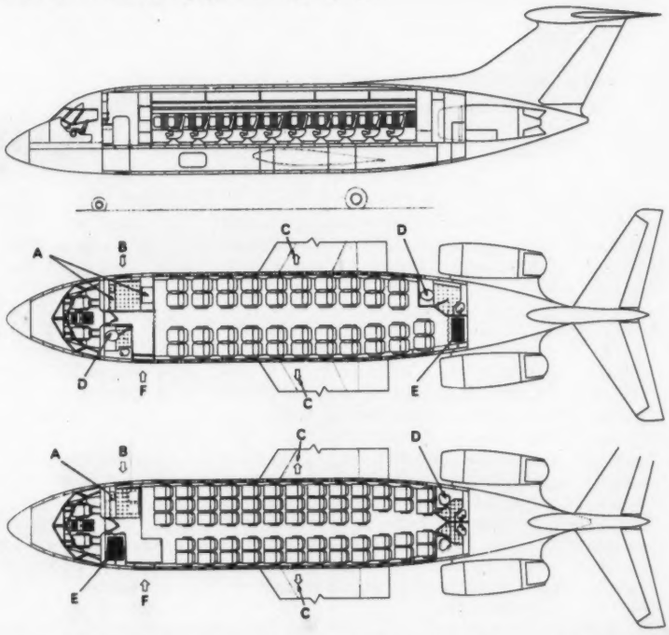
Barely had Bristol Siddeley announced the BS.75 by-pass engine when British airframe manufacturers were working out detailed designs for short-range aircraft which, powered by two BS.75s, could transport 40 to 60 passengers. The British Aircraft Corporation has taken up the Hunting 107 project, which was drawn up some years ago, and formed a team of engineers from Hunting Aircraft Ltd. and Vickers-Armstrongs (Aircraft) Ltd. to develop the aircraft to the construction stage. The fuselage and horizontal tailplane were modified, the project was brought into line with the new engines, and the aircraft is now to be offered to airlines under the designation BAC.107. Its transport performance will be roughly equivalent to that of the Vickers *Viscount* or the Convair *Metropolitan*, and the price is said to be under £500,000. For the 59 seat version of the BAC.107 the manufacturers have calculated direct operating costs of barely 1.2 cents per seat mile, and even in the standard version for 50 passengers (four seats per row) the operating costs are lower than those for the Vickers *Viscount 700*.

A. V. Roe and Co. Ltd. has also been carrying out comprehensive design studies in the past two years, which culminated in the announcement of the Avro 771 project at last year's SBAC Show at Farnborough. Also powered by two Bristol Siddeley BS.75s, this aircraft is designed to carry up to 60 passengers for distances of 500 nautical miles at speeds of about 500 knots. Both the BAC.107 and the Avro 771 will be able to take off and land in distances of under 5,000 ft. The cruising speed of the Avro 771 is slightly higher than that of the BAC.107, although the latter has a longer range. Both aircraft have high lift flaps; in addition, the Avro 771 has leading edge flaps which give it a maximum lift coefficient of no less than 2.4. The higher speed of the Avro 771 is doubtless due to its more sharply swept wing. An increase of the cruising speed above 500 knots did not appear justifiable, in view of the relatively low block speeds of short-range transport (short flight time and frequent stops).

Finally, de Havilland is working on a project for a twin-jet short-range aircraft with rear-mounted engines, which is planned as a successor to the four-engine *Heron* feederliner and will therefore doubtless be smaller than the two types mentioned above. Other British manufacturers are also closely following developments in the short-range market, in the hope that jet aircraft designed for civil operations may interest the RAF and other air forces as replacements for the obsolescent transports and navigational trainers of the Vickers *Valetta* and *Varsity* types.

Nothing is yet known of plans on the other side of the Atlantic, but the fact that many hundreds of DC-3s, Convair 240s, 340s and 440s, Martin 4-O-4s and Vickers *Viscounts* will one day have to be replaced, has kept the American aircraft industry on the alert. There is no doubt at all that when the airlines decide to modernize their short-haul fleets, they will have a rich variety of types to choose from. ⟷

The Avro 771 short-range jet—still only a project.



Fuselage layout of the 42 seat version of the Avro 771 (top and centre), and of the 60 seat version (bottom). A – galley; B – entry for crew and ground personnel; C – emergency exit; D – toilets; E – wardrobe; F – passenger entry.

Short range jet transports

Manufacturer and Type	Avro 771	BAC. 107	Manufacturer and Type	Avro 771	BAC. 107
Powerplant*	BS.75	BS.75	Max. payload (lb)	12,000	12,000
Thrust (lb)	7,350	7,350	Fuel capacity (Imp. gal.)	2,000	2,230
Span (ft)	77.46	81 ft 8 in.	Passenger capacity+	F42/E60	F50/E59
			Max. cruising speed (kts)	495	440
Length (ft)	80.37	84	Cruise altitude (ft)	25,000	25,000
Wing area (sq. ft.)	800	825	CAR take-off runway (ft)[2]	4,800	4,750
Wing sweepback[1]	30°	20°			
Cabin width (ft)	9.92	10	CAR landing runway (ft)	4,500[3]	5,050[4]
Max. take-off weight (lb)	52,000	48,500	Range with full fuel load (n. m.)	1,700	2,500[5]
Max. landing weight (lb)	50,000	46,000	Range with max. payload (n. m.)	500	950[5]

*BS = Bristol Siddeley +F = First Class, E = Economy Class
[1] At quarter chord; [2] Maximum take-off weight, ISA conditions, sea level;
[3] At 47,000 lb landing weight; [4] At maximum landing weight; [5] Without reserves

The BAC. 107, a short-range jet designed by the former Hunting Aircraft Company and developed by the British Aircraft Corporation.

The Convair 990

In November 1960, Convair announced the completion of the first Convair 990 and indicated that a programme of ground testing would then commence prior to flight testing in January 1961.

In making this announcement, Convair described the aircraft as a second generation jet airliner which embodies the design, production and operating experience of the Convair 880.

Normal commercial competition between the world's airlines has tended to focus attention on intercontinental journey lengths and the long-range jet aircraft. The shorter domestic routes also generate a considerable volume of traffic, but many of the airfields on these routes are unsuitable for regular operations by large jet aircraft in all weather conditions. In order to tap this market, it is obvious that the second generation jet must possess certain capabilities to enable it to fulfil these new requirements.

The Convair designers have aimed at producing a medium-range aircraft of high structural strength and high cruising speed to fulfil these conditions. The medium range is sufficient for domestic routes, and the structural strength is essential to combat the wear of repeated take-offs and landings on short journey stages. The high speed is an obvious requirement to make the jet commercially attractive both to potential airline customers and to the travelling public. The final requirement is for an aircraft which possesses the short field performance to enable it to operate from medium-sized airports.

In terms of range, the 990 has a fuel capacity for maximum range trips of 4,300 miles, or 2,860 miles at maximum cruising speed, with full fuel reserves in both cases. The maximum fuel load is 15,119 gal. for the 990 and 15,675 gal. for the 990 *Coronado*.

For added structural strength, thick fuselage and wing skins are used in the construction. Some sections of the fuselage skinning range up to ⅛ in. in thickness, and this also contributes to sound suppression in the cabin as well as structural reliability.

Special techniques have also been used in the construction of the wing structural members. The wing structure of an aircraft has always been one of the high cost maintenance items, and the new techniques will contribute to reduce these costs.

Scotchweld adhesive bonding is placed between the joining surfaces of the wing sub-assemblies during wing assembly, and the whole wing is then baked in an electric oven. After curing, the bonding provides a coating which protects the wing from corrosion from jet fuel and weather conditions. The coating has proved so effective that it even appears to resist the corrosive properties of Skydrol hydraulic fluid. This bonding process adds strength of about 25 percent to the wing structure and permanently seals the wing structural members to form leak-proof integral fuel tanks.

To provide the short field performance required for many domestic airports, the 990 is fitted with four slats on the leading edge of each wing, two between the engine pods and two outboard of the outer pods. The slats operate in conjunction with flaps, extending forward and down from the wing leading edge. On the trailing edge, full Fowler motion double-slotted flaps are fitted in board and half Fowler motion double-slotted flaps outboard.

Together with these high-lift devices, the 990 is equipped with a proportional anti-skid braking system which increases or decreases the brake pressure gradually to prevent wheel locking and skidding on wet or icy runways. Maximum braking effect can therefore always be obtained irrespective of runway conditions, to ensure minimum distance landing runs.

The wing design of the aircraft differs from the basic 880 layout by having an increased chord to reduce the thickness/chord ratio and to increase the wing area to a total of 2,250 sq. ft. for the greater operating weight of the 990. The design limit cruising speed of the aircraft is Mach 0.91, and the flow is supersonic over much of the upper surface of the wing. In order to reduce the intensity of the shockwave formed by this supersonic flow, four streamlined pods (described by Convair as "speed capsules") are fitted on the upper surface of the wing. The inboard speed capsules are 21.5 ft long and the outboard 24 ft long, and are 2 ft in width at the greatest diameter. The capsules project beyond the trailing edge of the wing and are flat on the underside, so that there is no interference with flap operation or the underwing airflow. The shape of these bodies offers a bonus to the designer as they are constructed as integral fuel tanks and contain approximately 1,000 gal. distributed between the four.

The first Convair 990 is rolled out in preparation for a programme of ground testing.

In high speed flight the forward portions of the capsules decelerate the supersonic flow ahead of the shockwave above the wing. This reduces the intensity of the shockwave and delays the flow separation from the wing and its attendant drag. The drag rise Mach number of the aircraft can then be increased to allow a higher cruising speed.

Another detail of the wing design is the absence of conventional aileron surfaces at the wing tips and the fitting of large size spoilers outboard of the outer speed capsules for lateral control. The sweepback of the leading edge is 39 degrees.

The aircraft is powered by four General Electric CJ-805-23 aft fan engines fitted with thrust reversers. The single-stage combined fan and turbine mounted behind the engine necessitates increased bypass airducts around the basic power plant, and the four underwing engine pods are in consequence nearly six feet in diameter. The engines are mounted ahead of the wing, so that the jet nozzles are approximately level with the wing leading edge in order to reduce drag.

The massive clamshell doors of the thrust reversers. In operation the doors move backward on the rail on the underside of the nacelle pylon.

To aid in braking after landing and to improve the short landing performance required for operation in small airports, thrust reversers are fitted to the four engines. Two steel clamshell doors which form the aft portion of the external pod when in the stowed position for normal flight, close to deflect the jet efflux to a 45 degree forward angle. To operate, the doors move aft on rails a distance of 27 inches before closing to obstruct the rearward jet flow.

The details already mentioned form the basis of this new "second generation" design: a high-speed wing with high lift devices for short field operation, economical and quiet fan engines with thrust reversing devices which will cause the minimum noise problems in airports close to residential areas, and finally a specially stiffened structure for repeated take-off and landing on short haul routes.

For success in commercial operations a further requirement is needed—ease and economy of maintenance. This has been built into the 990 by designing the various systems on a unit basis with a minimum of fastenings, connections and ducts. The units are built for maximum accessibility, to permit entire assemblies to be removed and replaced by others while the originals undergo maintenance and overhaul. The engine pods are so designed that by unfastening a few quick disconnect clamps, electrical connections and ducts, an engine is ready for removal.

Airframe accessibility is illustrated by the fact that almost 35 percent of the under surface of the wing consists of access doors and openings to mechanisms and systems. On the fuselage, about 12 percent of the area is made up of similar panels and openings.

The interior layout of the Convair 990 is designed to accommodate 96 passengers in four-across first class seating. When converted to five-across standard seating it can accommodate 121 passengers.

The aircraft will be certified to fly at 41,000 ft, but the normal high altitude cruise is 35,000 ft. A maximum cabin pressure differential of 8.2 p.s.i. is used, which gives a cabin altitude of 6,000 ft at 35,000 ft. Dual air conditioning systems recycle the cabin air every 2½ minutes, while a heat sensing system maintains a temperature differential of no more than 2 degrees Fahrenheit throughout the entire cabin, irrespective of passenger distribution.

The Convair 990 and its variant the 990 *Coronado*, which is an intercontinental version of the 990 with greater operating weights and fuel capacity but with equivalent performance, are representative of a new trend.

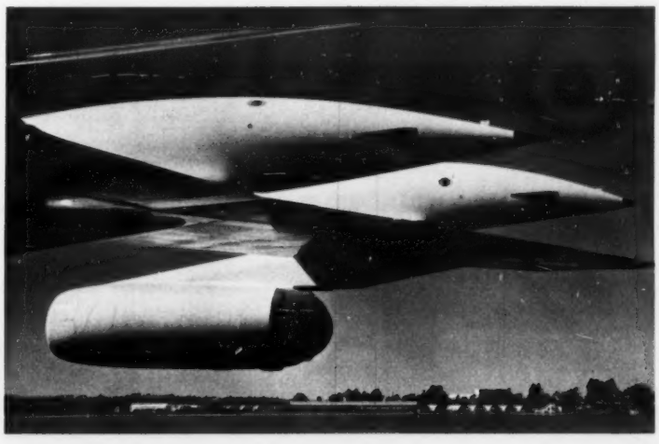
Despite the size, performance and weight of the aircraft, Convair claims that it can land and take off from most airports used by propeller-engined aircraft. This brings jet travel within the convenient reach of an entirely new market and will have a marked effect on the speed of domestic transport. A further advantage can be seen when aircraft of this type enter service. With the increased seating capacity offered by these aircraft the number of aircraft movements and the density of air traffic will tend to reduce slightly. This will lead to improved time-keeping and an even greater inducement to the passenger to travel by jet. ◆◆

Specification Details Convair 990

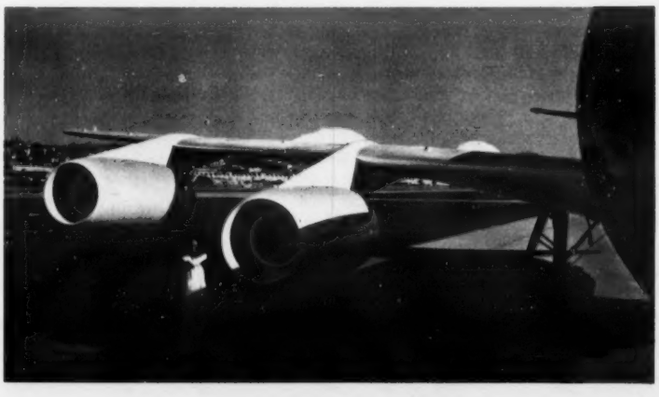
Cruising speed	640 n.m.
Range (long range cruise at 35,000 ft)	4,300 m.p.h.
Stalling speed	105 m.p.h.
Rate of climb (sea level, normal power, take-off weight)	3,250 ft/min
Take-off CAR runway for 2,000 st.mi. trip	5,350 ft
Take-off CAR runway for 1,000 st.mi. trip	4,600 ft
Landing CAR runway	4,770 ft
Span	120 ft
Length	139 ft 5 in.
Height over tail	39 ft 6 in.
Max. landing weight	180,000 lb
Max. take-off weight	239,200 lb (*Coronado* 244,200 lb)
Max. zero fuel weight	154,000 lb

Engines

4 General Electric CJ-805-23 aft turbofan engines equipped with thrust reversers. Thrust, standard day: 16,100 lb each.



The two speed capsules on the starboard wing of the 990. Apart from the aerodynamic function of the capsules, they also serve as additional fuel tanks.



Two of the General Electric CJ-805-23 aft fan engines, with the entry ducts for the fan and the basic engine.

Boeing Experience with Jet Airliners

The jet airliner—or rather its designer—never stops learning. When it has been in scheduled airline service for some time, the maturing period begins, during which the experience of users is assessed and small but none the less essential modifications are made. The following report is based on a paper read by Harold P. Luiten, of the Transport Division of Boeing Airplane Company, at a technical conference of the Air Transport Association of America in Kansas City, Missouri, in October, 1960. Although Boeing is not the only manufacturer to have gained valuable experience with jet airliners in past years, the editors feel that Harold P. Luiten's observations are descriptive of the efforts of the entire aircraft industry to overcome the "teething troubles" which inevitably accompany the introduction of revolutionary new aircraft types. Editors

It is now 2½ years since Boeing jet airliners went into scheduled service, and since the first days of autumn, 1958, their utilization has been astonishingly high. Although there has been considerable variation between airlines in the utilization achieved, the majority of the differences can be attributed to route structure, schedule frequency and training rather than to differences in mechanical reliability. In general, however, it can be stated that aircraft maintenance has not limited utilization. As an example of the 707's capability, one airline has maintained it at 11 to 12 hours daily utilization.

Improvements to certain systems of the 707 series during this period have resulted in such a high degree of reliability that any slight mechanical hitches which may occur are attributable solely to the unforeseeable failure of certain minor components. Boeing engineers are of the opinion that further system improvements would be uneconomical to achieve, as they would cost more than the gain would be worth. The company has nevertheless spared no effort to attain the highest possible degree of quality, and its endeavours are reflected in the following typical examples.

Water injection system for the engines

The water injection system for the four jet engines was a relatively new item, and one which requires high capacity operation for a short period. From the beginning, this system turned out to be one of the major sources of mechanical failure, its least reliable component being the engine-driven water pump, whose bearings and control valve were continually causing difficulties despite the fact that design specifications were scrupulously observed. No sooner had these defects been eliminated than water line tubing failures began to show evidence of possible surges in the system. To save time, Boeing decided on an emergency solution, the provision of separate surge chambers.

Hydraulics

Early service experience indicated that hydraulic pump failures and loss of hydraulic fluid were causing a number of in-flight emergencies. Some of these failures occurred at times when jet incidents were receiving a great deal of publicity and were magnified out of all proportion by the press. After pump seal failures had been pinpointed as the source of the fault, Boeing struck out along two different lines to find a remedy. Firstly, the pump manufacturer was asked to undertake a long-term programme to develop a means of eliminating the surges within the pump itself; secondly, as an interim measure, Boeing fitted a by-pass circuit which in a majority of the instances reduced the pump failure rate. Even after the by-pass circuit had been fitted, however, incidents continued to occur on specific aircraft; but investigations by Boeing engineers indicated that these were due to a lack of proper system maintenance and control. This necessitated the revision of maintenance procedures for the hydraulic system, and a team of specialists was sent to airline maintenance depots to evaluate practices.

Foreflaps

Several foreflaps were lost owing to a combination of fatigue and extensive operation with trailing-edge flaps down, particularly during training flights. As a result, reinforced end ribs and inertia dampers were fitted to aircraft already delivered and to those still under construction.

Landing gear

Despite thorough laboratory testing, the Boeing 707 landing gear did not meet the exacting demands of airline operation. In a number of cases, the outer cylinder in the torsion lug area failed. Since the type of failure that was experienced did not lend itself to repair by the airlines themselves, a twofold programme had to be instituted to keep the aircraft flying. Firstly, an inspection programme was initiated to ensure the airworthiness of the existing oleo outer cylinders; the sharp edges of the attach lugs were milled down to reduce stress concentrations. Secondly, the cylinders were redesigned and put into production as soon as the design was finalized. At the present time, new outer cylinders are becoming available at a rate that will permit all aircraft to be fitted by the end of 1961. For the inspection of the landing gear of all aircraft at present in service, Boeing used highly advanced penetrant, magnaflux and sonic techniques of the type normally employed for production control in industry.

Air conditioning

The air conditioning plant, too, proved inadequate for operations during the hot summer months. After finding the reasons for this, Boeing mechanics fitted dozens of 707s with improved air conditioning systems at Los Angeles Airport, the maintenance base of a number of airlines, at a cost of 16,199 man-hours, which was borne by the company.

Further defects in the *latch mechanism of the fuel dump chute*, the *starting system* and the blocking valves of the *hydraulic leading edge flap actuator system* of the 707 and the *leading edge flaps* of the 720 were eliminated in the same way as the faults described above.

Improving the flight characteristics

During the two years following the flight testing of the first 707s, Boeing Airplane Company undertook an extensive wind tunnel and flight test programme with the aim of achieving improvements in handling and performance. The results obtained induced the management to make certain improvements on 707s already in production; the changes did not in any way affect certification, which was already completed. It was also decided to make kits of parts available for retrofitting aircraft which had already been delivered, the work being carried out either by Boeing or by airlines concerned. The major changes in the Boeing flight characteristics improvement programme are a fin-tip extension and ventral fin installation, incorporation of a full-range hydraulic boosted rudder, changes in the rudder trim system and a change in the aileron trim system. The addition of a full-range rudder boost system not only improved directional stability (by eliminating the floating rudder), but also reduced the pedal forces required by the pilot during normal flight, particularly in cases of asymmetrical thrust during an engine-out condition.

A programme of such magnitude naturally required the close cooperation of all sections of the Boeing engineering and manufacturing organizations. Negotiations with each customer determined how the changes were to be made on aircraft already delivered. Some airlines preferred the modifications to be made to aircraft at the Boeing Renton plant while they were being converted to a "B" configuration with turbofan engines and a leading-edge glove. Other companies wanted the modifications made at the Boeing plant, even though they did not require conversion to the "B" version. Certain smaller companies outside the USA decided to incorporate the changes at their own facilities along with other overhaul work, with the assistance of teams of Boeing engineers.

In order to maintain continuous contact between Boeing engineers operating throughout the world and the design and service headquarters at Renton, near Seattle, the company linked all its overseas sales offices and spares depots with Renton by a direct teletype system, which is totally independent of Boeing's normal teletype system.

A special service analysis unit at Renton regularly records and evaluates reports from the users of all Boeing jet airliners to obtain statistical data on certain sources of trouble which are not apparent from the statistics of a single operator.

As jet aircraft go into service at a considerably higher rate than did former piston-engine types, the spares supply service must also operate more rapidly. It was not long before Boeing realized the fallacy of attempting to supply airlines all over the world from a single factory source at Renton, and accordingly set up other spare parts stores at New York International Airport and at Orly.

The first aircraft to profit from the experience collected to date are, as already mentioned, the 707 and 720 series. The full benefit will, however, be felt by the coming generation of jet airliners, whose first representative, the Boeing 727, is rapidly nearing the end of its development phase. ↔

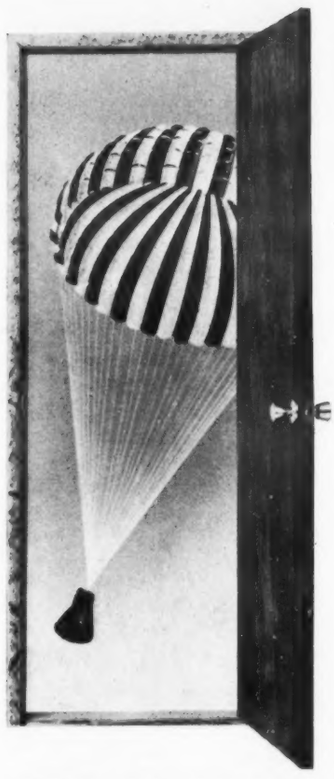
Forty flying years

Albert Plesman founded KLM in 1919. The Royal Dutch Airline is thus the oldest-established of international operators, and pathfinder of many well-used world routes, especially to and through the Far East. Today, KLM flies DC8's through to Australia over trails blazed in part by Plesman's pioneers.
At Sydney AIR BP fuels KLM's new aircraft with the speed and precision that new jet turn-round schedules demand.

Fast flying KLM ROYAL DUTCH AIRLINES *... fast fuelling* AIR BP

POLARIS: Northrop's Datico checks out Polaris at all levels of maintenance and operation.

SKYBOLT: Guidance and navigation systems are being developed by Northrop for this new and highly secret air-launched ballistic missile.

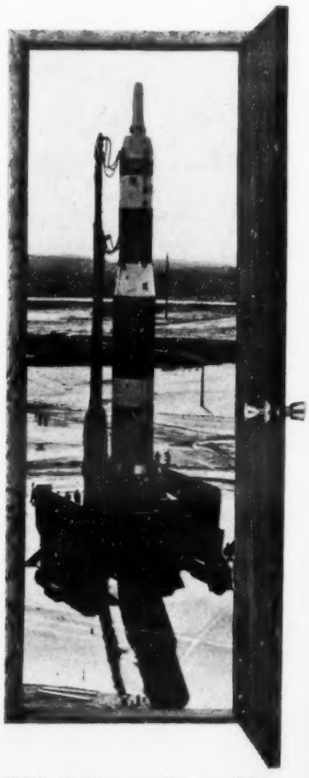


MERCURY: The Northrop landing system is designed to bring the Mercury astronaut down safely.

Northrop is now active in more

X-15: Northrop produces Q-Ball, the flight angle sensor for safe re-entry of X-15 and other aerospace vehicles.

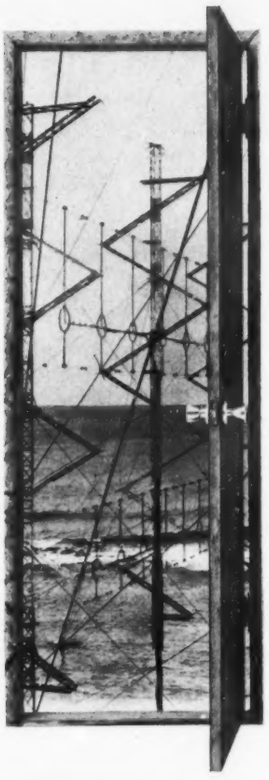
AERODYNAMICS: Northrop's Laminar Flow Control technique is designed to greatly increase aircraft range, flexibility, cargo and passenger capacity.



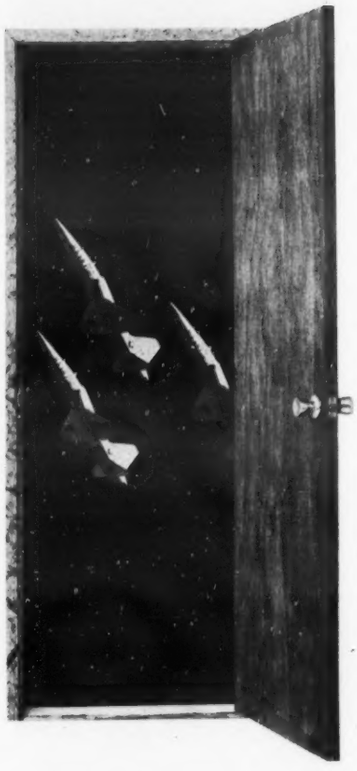
TITAN: Northrop supplies complete technical and industrial management to activate the T-2 Titan missile base.

Northrop Corporation, Beverly Hills, California • Divisions: Norair, Nortronics, Radioplane, Northrop International

HAWK: Northrop produces airframe components, ground handling and launching equipment for this air defense missile.



COMMUNICATIONS: Northrop designs the trans-Pacific Scatter Communications Network and other worldwide communication systems for U.S. and free world governments.



T-38: World's first supersonic twin-jet trainer is built by Northrop for the United States Air Force.

than 70 important programs

TARGET MISSILES: Northrop has produced more than 50,000 electronically-controlled aerial targets, and surveillance drones.

COMMERCIAL METAL PRODUCTS: Northrop produces aluminum architectural shapes for many important industrial and commercial buildings.

SPACE RESEARCH: Northrop's accelerated space research programs reach into such advanced areas as maneuverability, rendezvous, space vehicle maintenance, space probes, and the survival of men in space.

Subsidiaries: Page Communications Engineers, Inc., Acme Metal Molding Company.

GYROSCOPES

FLIGHT CONTROL
FLIGHT REFERENCE
STABLE PLATFORMS
MISSILE GUIDANCE
SPACE NAVIGATION
INDUSTRIAL

WORLD LEADERSHIP IN
PRECISION GYROSCOPICS

SANTA MONICA, CALIFORNIA, U.S.A. • MUNICH, WEST GERMANY **LEAR** GENEVA, SWITZERLAND

A Manufacturer's Assessment of Sales Prospects

By E. F. Burton, Vice President, Engineering, Douglas Aircraft Company

Although some may be inclined to disagree, the facts seem to indicate that the era of turbine-powered transport aircraft has been launched successfully. Unresolved problems relating to terminal facilities, air traffic control and environmental nuisance cannot obscure the manifold blessings of the propellerless airplane.

Jet traffic statistics speak eloquently for passenger preference; and, as operators become more intimately acquainted with their new equipment, their decisions to mortgage future earnings to acquire the jetliners appear less foolhardy than was predicted by some sceptics. As a type, the pure jet airliner is proving to be structurally rugged, mechanically dependable and operationally profitable. Attractiveness of propeller-driven aircraft is diminishing with the rise of the jets.

To those of us for whom prediction is an occupational necessity, the portent is clear. We foresee a progressive substitution of jet-powered aircraft for existing propeller types in all categories of service—long, medium, medium-to-short and short ranges for passengers and long and medium range for cargo. It may take some time to complete the transition, but the trend is inexorable because it is sound.

Armed with this knowledge, an airframe producer turns first to his market analysts to forecast probable airlift requirements, as a guide to how many aircraft might be needed. Reasonably reliable figures may be adduced for total passenger miles or ton miles, respectively. It is more difficult to break down the total traffic into probable trip lengths. This latter information, of course, is most important since it bears directly on aircraft size.

Our study of the market also includes high level personal discussions with airlines whose individual requirements have a strong influence on decisions we might make to proceed with a new airplane type. It should be noted, further, that the entire process is continuous—calling for constant revision of data on which forecasts are made and of possible airframe configurations.

Let us examine what some of our recent data indicate. First of all, there will be a continuing growth of world passenger traffic. The ICAO report of world air passenger traffic for 1960 shows a total of 69,000 million passenger miles flown. Our forecast is that this total will rise to 105,000 million by the end of 1965 and to 175,000 million passenger miles in 1975.

To meet that increase in traffic, the world's airlines will need at least three times as many airplanes. They will also want to retire many propeller-driven aircraft or, as many are now doing, convert them for cargo use.

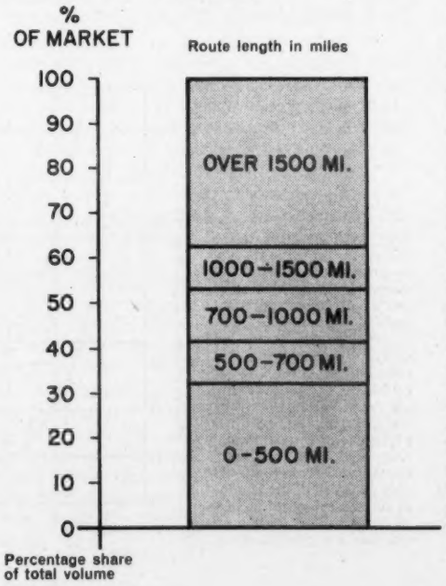
We see a need for more long-range jet airliners, probably growth versions of existing types using the higher efficiency turbofan engines. In the next five years, these aircraft may be expected to be enlarged sufficiently to make nonstop flights between extremely distant cities while carrying sizable payloads. These will be subsonic aircraft with practical speeds under 600 m.p.h. and weights between 315,000 and 350,000 lb.

Since not all traffic will be over the extreme ranges, there will be a need also for medium range subsonic jets for operation over 1,000 to 3,000 miles. Some of this type are already in existence and more are nearing service, but the numbers will at least double during the next decade.

We anticipate a large expansion in the field of short-to-medium range jet transports for efficient operation over flight stages of 700 to 1,200 miles, a significant portion of the projected air travel market. Aircraft now being offered to meet this requirement include advanced versions of the Sud Aviation *Caravelle* and the Boeing 727.

A reference to the diagram indicates that more than 40 percent of air travel will be over ranges less than 700 miles. Although jets of the DC-8, 707 and 880 class can operate profitably over some of these routes, where the traffic is sufficiently dense, a large portion of this travel market cannot profitably be served by currently available aircraft. If, indeed, the world's airline fleets will all be converted to jets, there will remain a large unsatisfied need for a true short-range transport. This would be an airplane weighing from 50,000 to 75,000 pounds and carrying from 40 to 60 passengers.

The respective shares of long-, medium- and short-range transport in the total air transport volume. As the graph shows, route lengths of up to 700 miles account for over 40 percent of the total world air transport volume. In other words, there is an urgent need for a new, high-performance short-range jet airliner.



And finally, there is a definite need in the world for a commercial carrier with VTOL or STOL capability, to complete the transportation links which now terminate in large centers of population. We are not as certain about this category as we are about the others because all previously mentioned aircraft are already well within the state of the art. With the present effort, however, we feel such an aircraft will be produced within the decade.

To complete the passenger transport category within the time period under consideration, we must include a long and possibly a medium range supersonic transport. The market for the supersonic jet will be limited to express traffic between large population centers, and we do not expect to see these aircraft in service much earlier than the 1970s.

Since air cargo traffic is growing at a rate faster than that for passengers, there is a tremendous potential for subsonic jet-powered cargo transports. Recent conversion of partially depreciated piston transports into high speed cargo planes is providing a stimulus which can put airline operators into position to order cargo jets. Our market forecasts on cargo are based on preliminary data, but we do know that if the ton mile tariffs can be reduced, the growth will be greater than if they remain at or near the existing costs. The findings also indicate the possible creation of an entirely new category of air cargo if the ton mile rates are sufficiently attractive.

Douglas has detailed studies on commercial jet airliners which can operate at such attractive tariffs. We expect, within the next decade, to see a number of turbofan powered jet transports with extreme long range capability in airline service. However, to realize the full potential forecast for air cargo, the airplane must be an integral part of an entire system which includes proper group handling equipment, efficient packaging and faster processing of shipping information.

The outlook, then, is for great new fleets of jet transports for every purpose in service before the mid-1970s. Which ones will be produced by Douglas will depend upon our best estimate of the market requirements at the time we are prepared to begin production.

Conclusions Drawn from Flight Experience

Atmospheric Phenomena Connected with the Jet Stream

By Flight Captain Willibald Partl, Lufthansa, Hamburg

The term "jet stream" denotes a relatively restricted zone of high-altitude, high-velocity winds. In accordance with Buys Ballot's Law, which was discussed in an earlier article [1], wind is a direct function of the horizontal pressure differences in the atmosphere. A jet stream would thus be identical with a relatively restricted zone of pronounced pressure gradient, in other words, where the constant pressure surface slopes steeply.

The validity of this conclusion, which in itself appears perfectly logical, has, however, been dispelled by practical experience. Taking as a basis the wind speed measured in a jet stream, the inclination of the probable constant pressure surface can be calculated with the aid of the D value and compared with the slope measured in flight. In jet streams at an altitude of 36,000 ft, the wind speeds observed have been up to 40 percent higher than was indicated by the slope of the constant pressure surface. Even at intermediate tropospheric altitudes (around 20,000 ft), similar phenomena have been encountered from time to time.

Observation of this phenomenon over a long period—particularly on the North Atlantic route—has shown that these deviations from Buys Ballot's Law invariably occurred under a given set of temperature conditions. This situation, which is important for both aviation and meteorology, will be dealt with in detail in the present article.

In the intermediate and upper layers of the troposphere (between 15,000 and 32,000 ft), high D values occur in connection with high temperatures. On a flight across the sea at a constant pressure altitude (i.e., with constant pressure altimeter indication), the relation between these two values can be found. Here certain changes in D values are accompanied by corresponding changes in temperature. This confirms the assumption that there is in the atmosphere a kind of equilibrium at which the conditions of Buys Ballot's Law are fulfilled—i.e., wind speeds correspond to the isobaric slope. If, however, in exceptional cases, the distribution of temperature is unequal over a constant pressure pattern, an airflow is generated in addition to the wind caused by the general distribution of pressure, an airflow which moves in such a direction that the local abnormal temperature pattern once again corresponds to the general pressure pattern. The equalizing flow, in which one mass of air slides over another, is known as isentropic thermal shear, the associated rising and falling of the air masses concerned "adiabatically" restoring the temperature pattern appropriate to the pressure area; the process will be described in detail below. In general, these virtually horizontal air movements, which are governed by temperature, take place in a restricted region, in which they act as "ageostrophic" components, disturbing the regularity of the general wind pattern. Before this phenomenon is discussed in detail, a few meteorological principles should be recalled.

It is first of all important to know that the atmospheric pressure decrease depends on the temperature of the air masses concerned as height increases, or, more properly speaking, from the vertical temperature pattern. *Fig. 1* shows two columns of air—one cold, one warm—which exercise the same pressure on the earth's surface and are hence of equal weight. Because of the higher specific weight of the cold air, pressure in the cold air column will drop more rapidly as height increases than it will in the column of warm air. If an aircraft moves horizontally, i.e., at a *constant absolute altitude*, the pressure altimeter will show a higher value in cold air than it will in warm air. With barometric hold control, however, the aircraft will normally remain at a *constant pressure altitude* ("isobaric flight"). If, say, a pressure altitude of 20,000 ft is maintained, the aircraft will gain absolute height, in other words it climbs as it passes from a zone of cold air to a zone of warm air. In *fig. 1* the gain in altitude with an average temperature increase of 10°C is 700 ft.

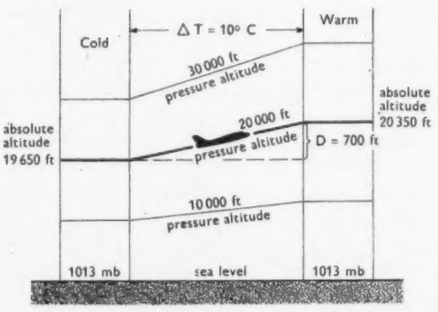


Fig. 1: In cold air, pressure drops more rapidly with increasing altitude than it does in warm air. Assuming the same sea level pressure (1,013 mb), a certain pressure altitude, e.g., 20,000 ft, lies lower in cold air than it does in warm air. In the example shown, a temperature difference $\Delta T = 10°C$ gives a difference of 700 ft in altitude. The D value alters in the same proportion.

The slopes of constant pressure surfaces caused by differences in temperature increase with altitude. According to Buys Ballot's Law, however, wind speeds increase in the same ratio as slopes, as altitude is gained. It can therefore be said that wind speeds at high altitude are determined primarily by the average temperature of the air masses lying beneath.

Assuming equal surface pressure, the relationship between the change in altitude of a constant pressure surface and the change in the average temperature of the air beneath it can be expressed mathematically, in the form of a "PDT table" (P = pressure altitude, D = D value change, T = temperature change). From such a table (*fig. 2*) can be read the expected change in average temperature (ΔT) for each constant indication of the pressure altimeter (P) and each change in absolute altitude (ΔD), read over the sea from a radio altimeter.

In the course of a pressure pattern flight, the navigator can check, by regular observation of changes in D value and temperature, whether the relationship indicated by the PDT table is correct,

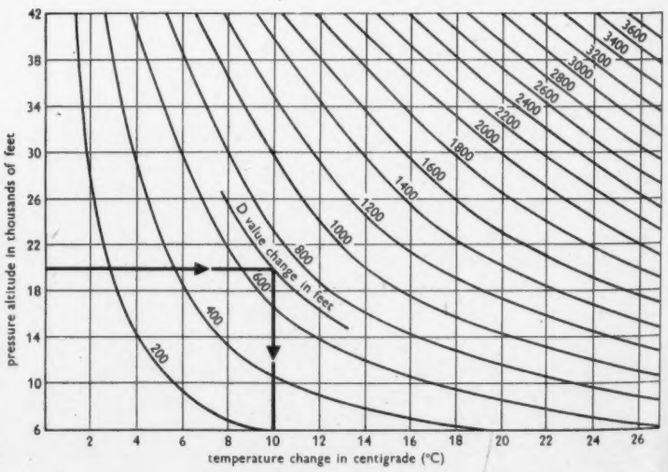


Fig. 2: The PDT table shows the connection between pressure altitude P, average temperature change ΔT of the lower air mass and D value change ΔD. If, for instance, an aircraft is flying over the sea at a constant pressure altitude of 20,000 ft and the radio altimeter reading climbs by 700 ft during the flight, the average temperature should rise by 10°C. Strictly speaking, account should also be taken of the change in surface pressure; at very high altitudes, however, this has a negligible effect.

[1] W. Partl, "The Basic Principles of Pressure Pattern Navigation," *Interavia*, No. 8/1960, p. 986.

or whether there is a DT discrepancy. The latter means that the temperature actually measured can provide no basis for a knowledge of the average temperature of the column of air directly under the aircraft. The true temperature pattern must therefore diverge from that obtaining in a state of atmospheric equilibrium. The observation of temperature in pressure pattern navigation has shown that the pressure pattern method is inaccurate when DT discrepancies are great, i.e., when the temperature changes very sharply. This phenomenon is important for an explanation of the jet stream.

The consequences of a DT discrepancy can be shown by means of a simple example. For the sake of simplicity, let us take a perfectly horizontal constant pressure surface, say 1,000 mb. This means that the D value change is nil in every direction—in other words, there is no wind. In a normal PDT relationship, therefore, there should be no change in temperature. Let us now assume that a "discrepancy" exists, that a limited zone of this constant pressure surface has a higher temperature than its surroundings. To give a concrete instance, let us take the case of a closed hangar, inside which the air is slightly warmer than outside. Because of the windows at mid-height, the 1,000 mb pressure surface is at the same level inside the hangar as it is outside (*fig. 3*). When the hangar doors are opened (*fig. 4*), a cold draught comes flowing into the hangar along the floor, and the warm air rises to the upper section. As long as the doors were closed, the DT discrepancy resulted in a "shear stress" along the constant pressure surface; the upper part of the shear stress pressed outwards against the hangar doors, the lower part inwards. As soon, however, as free atmospheric conditions are restored, the upper and lower air masses begin to move in opposite directions. Once the doors are opened, the air which is "too cold" for the constant pressure surface slides under the warm air at levels determined by the vertical temperature distribution (isentropic surfaces). It leaves the 1,000 mb level and comes under higher pressure, thus becoming slightly warmer. The warm air from the hangar slides out over the incoming cold air and comes under lower pressure, thus becoming slightly colder. The final effect of this phenomenon is that the temperature differences cancel each other out, so that the DT discrepancy which caused the movements of the air masses is eliminated. Despite the geostrophic still air conditions, the DT discrepancy has caused shear winds over a limited area, which continue until the balance is restored between the air inside and outside the hangar. This small-scale example of shear flows conditioned by temperature is a good illustration of the phenomenon observed when DT discrepancies are encountered in flight. This can be formulated as follows:

"Where the variation in temperature at flight altitude is greater or less than it should be to correspond with the slope of the constant pressure surface on which the aircraft is flying, opposed airflows are generated in a limited area; their directions are such that they tend to eliminate the DT discrepancy, the sum of the airflows with respect to their surroundings being nil."

In the case of a sloping constant pressure surface, where a geostrophic wind already exists, the shear winds are superimposed on the geostrophic wind, altering its direction and/or speed.

Here is a practical example: an aircraft is flying at a constant pressure altitude of 18,000 ft. The absolute altitude determined by radio altimeter rises by 200 ft (therefore $\Delta D = +200$) and the temperature by 12°C. According to the PDT table the temperature should normally rise by only 3°C, and a discrepancy therefore exists. *Fig. 5* explains this situation in greater detail. The temperature on the sloping constant pressure surface is too low at point A and too high at point B. The airflows thus caused on both sides of the area of discrepancy are marked with arrows.

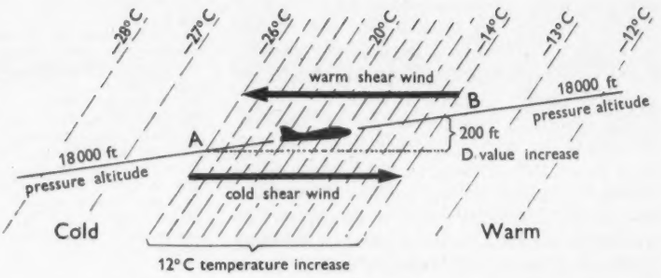


Fig. 5: Typical example of a DT discrepancy. On the way from A to B the pilot is flying at a constant pressure altitude of 18,000 ft; he notes a rise in absolute altitude of 200 ft, corresponding to a D value increase of 200 ft. At B the thermometer reading is 12°C higher than at A, although the PDT table indicates that it should be only 3°C higher.

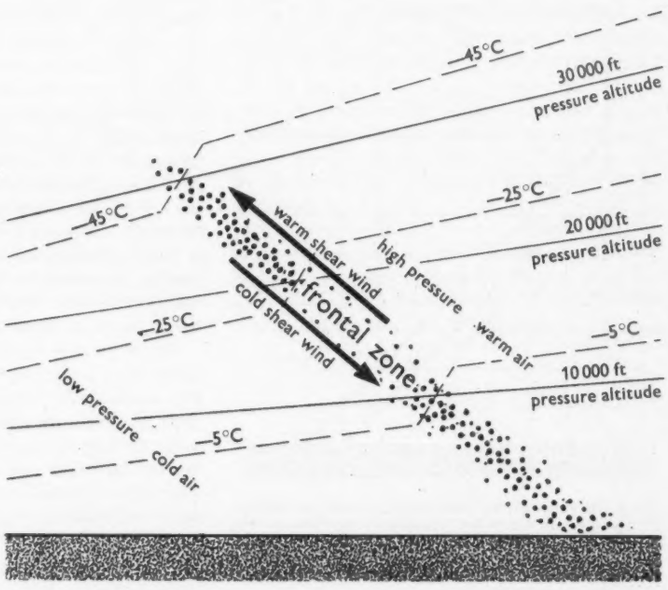
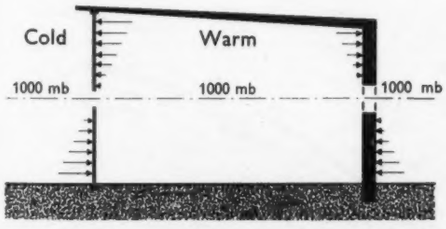
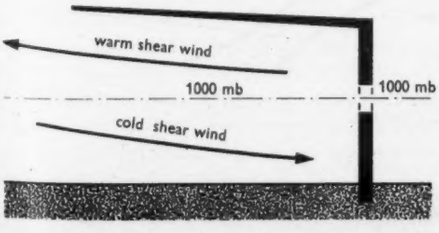


Fig. 6: Diagram of a frontal zone in which low-pressure cold air comes into contact with high-pressure warm air. The difference in pressure generates a balancing airflow. As a result of the DT discrepancy, a warm and a cold shear wind are superimposed on the geostrophic wind. As all wind components, except those at the equator, are deflected by the Coriolis force, the resulting airflow is perpendicular to the plane of the drawing.



Figs. 3 and 4: Diagram showing a shear effect on a restricted scale, resulting from a difference in temperature in contiguous layers of air. In an aircraft hangar with closed doors the temperature of the air is a few degrees warmer than outside the hangar. Open windows in the back wall and doors equalize the pressure inside and outside the hangar at half height: internal pressure = external pressure = 1,000 mb. Because of the different specific weights of cold and warm air, there is an under-pressure in the hangar below the 1,000 mb level; above the 1,000 mb level, however, there is an over-pressure (upper picture). After the doors are opened, cold air (cold shear wind) flows into the hangar along the floor, forcing the warm air out at the top (warm shear wind), until equilibrium is restored (lower picture).



Here consideration should be given to an effect which causes large-scale movements in the free atmosphere to differ from those in the hangar, namely the effect of the earth's rotation, or Coriolis effect. The arrows in *fig. 5* indicate merely the direction of the pressure which causes the air masses to begin to move. As explained in an earlier article [2], airflows in moderate and high latitudes are deflected by Coriolis forces, at times by as much as 90° from the direction of the original pressure gradient. The inclined constant pressure surface in *fig. 5* shows a low-pressure area to the left and a high-pressure area to the right. Without Coriolis forces, winds would blow directly from right to left. But the earth's rotation causes a deflection, so that the actual direction of the wind lies perpendicular to the surface of the drawing. The initial direction of the independent wind component resulting from the DT discrepancy is also right to left on the warm air side. But this flow, too, if generated on a large scale, is

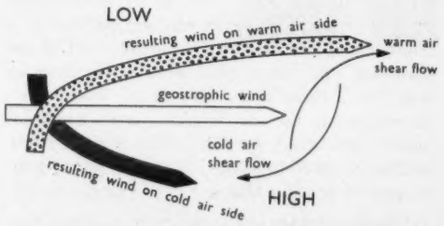


Fig. 7: A horizontal section taken perpendicular to the plane of *fig. 6*. It can be seen that the shear flow increases the force of the geostrophic wind on the warm air side and decreases that of the wind on the cold air side.

[2] W. Partl, *ibid.*

deflected to the right and added to the geostrophic wind. Conversely, the thermal shear flow of cold air to the left will move in the opposite direction to the wind caused by the general distribution of pressure, thereby lessening its force.

The numerical example chosen is, however, infrequent, for such a pronounced DT discrepancy occurs only in the zone of a true boundary between air masses, or frontal zone. If the situation shown in *fig. 5* is placed in its natural surroundings, the result is the diagram of a frontal zone (*fig. 6*). Along the boundary surface, which

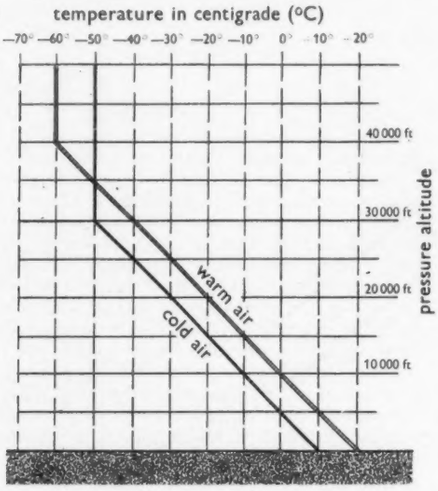
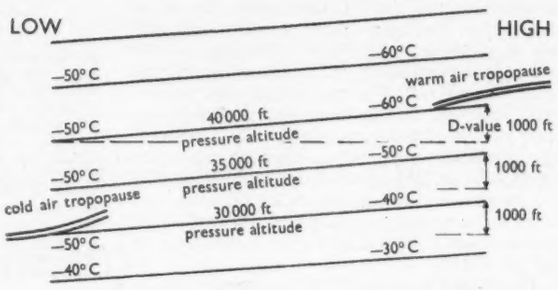


Fig. 8: In warm air the tropopause generally lies higher than in cold air. Up to the tropopause, temperature falls linearly as altitude increases, remaining constant in the stratosphere above. Consequently, the temperature distribution is reversed, at a pressure altitude of 35,000 ft in the present example.

runs from top left to bottom right, well-defined temperature steps can be observed in the various constant pressure surfaces, while the constant pressure surfaces themselves run rectilinearly through the frontal zone without changes in slope. (A local increase in the slope of the constant pressure surface, which would correspond to the sudden rise in temperature in accordance with the PDT table, does not exist in the free atmosphere). The shear winds described above arise on both sides along the entire boundary surface, and as a result the wind on the warm air side of a frontal zone has a force above its geostrophic force, while the wind force is less on the cold air side (*fig. 7*). From the pilot's point of view, on a flight path running parallel to a frontal zone the aircraft has a tail wind in the warm air side and a head wind in the cold air side. On a flight from cold air to warm air—perpendicular to the frontal zone—the cross wind is less before the aircraft reaches the front, and more after it passes the front, than is indicated by D value changes.

The discrepancy discussed here in connection with the frontal zone is due to the fact that the temperature rises and falls with the D value, though by a disproportionate amount. There is, however, another case, which is of far greater importance for jet transport, in which D value and temperature move in opposite directions, e.g., a rise in D value is accompanied by a drop in temperature. This case, which is the complete antithesis of the principle expressed in *fig. 1*, is most frequent at the boundary between the troposphere and the stratosphere, the so-called tropopause. The reason for it lies in the different upper

Fig. 9: The figure shows the situation in fig. 8 particularly clearly. The 30,000 ft, 35,000 ft and 40,000 ft constant pressure surfaces are 1,000 ft higher on the HIGH side than on the LOW side; the D values will therefore also increase by 1,000 ft. At a pressure altitude of 30,000 ft the temperature increases by 10°C from LOW to HIGH, corresponding exactly with the PDT table. At 35,000 ft the temperature remains unchanged despite the change in the D value; at the 40,000 ft pressure altitude the temperature even falls between LOW and HIGH, resulting in a temperature discrepancy of 17°C and hence violent shear winds.



limits of the warm and cold air masses in the troposphere; cooling with increasing altitude is completed sooner in relatively cold air than it is in warm air. In cold air, the tropopause often lies at 30,000 ft (pressure altitude), at a minimum temperature of —50°C. Above, in the stratosphere, the temperature is virtually constant. An air mass which is, on average, 10°C warmer, on the other hand, completes its cooling only at 40,000 ft, reaching a minimum temperature of —60°C. Paradoxically, therefore, the upper limit of the warm air is 10°C colder than that of the cold air; in other words, the tropospheric warm air has a "cold cap."

Fig. 8 gives a schematic presentation of this situation. The two lines show the intersection of the temperature values at 35,000 ft. In this example, this is the altitude at which the distribution of temperature is reversed: the warmer air lies on the LOW side, the colder on the HIGH side. *Fig. 9* shows this situation in a different way: At 30,000 ft, "normal" tropospheric conditions prevail on both sides, for the lower side of the constant pressure surface should be 10° colder than the higher side. At 35,000 ft a discrepancy already exists, as there is no difference in temperature despite the slope of the constant pressure surface. Finally, at 40,000 ft, maximum discrepancy is found. The temperature drops by 10°C from LOW to HIGH, although the PDT table shows that it should rise by 7°C. In this area of maximum discrepancy (17°C), therefore, violent shear winds are generated. The shear flows generated by the "reciprocal" temperature distribution at this point result from the shear pressures, which are indicated by arrows in *fig. 10*. The shear pressure of the upper, extremely cold air in the region of the HIGH tropopause (cold cap) is exerted in the same direction as the Buys-Ballot pressure field, which is recognizable from the slope of the constant pressure surface. The stream of old air, which initially follows the direction of the arrow, is deflected by the Coriolis force and adds a component of direction and force to the geostrophic wind, which blows in a direction perpendicular to the surface of the drawing and which is at its maximum force at these altitudes. As, however, it has been seen that shear winds are generated by two flows which tend to cancel each other out, the intensification

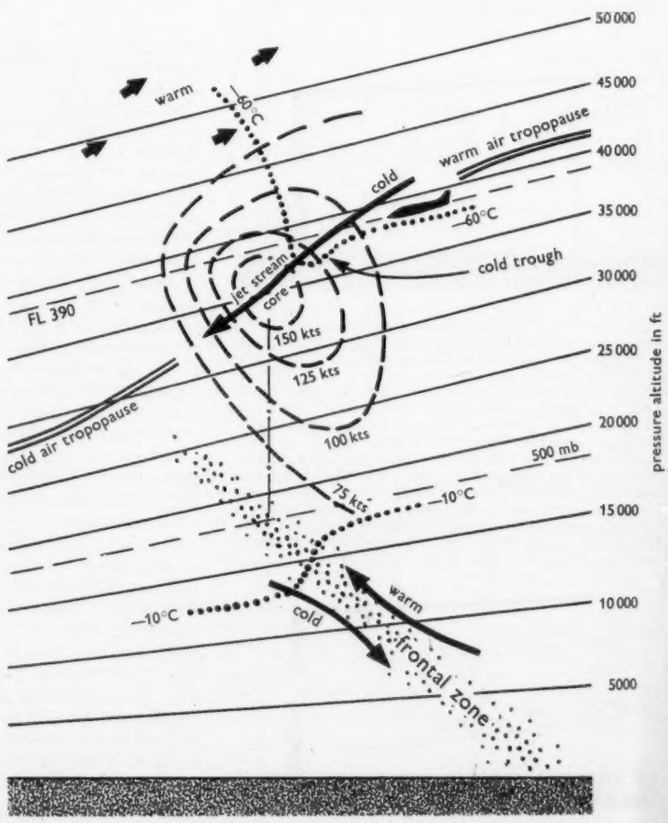


Fig. 10: Vertical cross-section of a jet stream. The direction of the wind is perpendicular to the plane of the drawing. The maximum wind force, i.e., the core of the jet stream, here over 150 knots, lies over the point at which the constant pressure surface of 500 mb intersects a frontal zone. For further explanations see text.

of the geostrophic wind must be succeeded byits attenuation. From the distribution of temperature it must be assumed that above the jet stream core the wind lies slightly below its geostrophic value, being spread over a relatively wide altitude range in the stratosphere (*fig. 11*).

The flow of cold air from the HIGH to the LOW tropopause over a tropopause gradation can be easily ascertained with the thermometer at altitudes above the jet stream core. If, for instance, an aircraft is flying at 39,000 ft (FL 390) from HIGH to LOW (*fig. 10*), as D values steadily decrease the temperature will first drop slightly, rising only when the aircraft enters stratospheric air. This "cold trough" in the temperature curve is a sure sign that one is entering the stratosphere from the troposphere. The aircraft penetrates the cold coat of the warm air caused by the sideward flow of the air from the cold cap.

But where can the jet stream core be found?

Anywhere where the upper layers of high tropospheric warm and cold air masses border each other. Between the equator and the poles, there are a number of gradations in the average tropospheric temperature and hence a number of gradations in the tropopause. Experience has

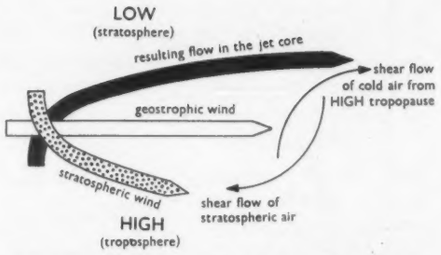


Fig. 11: Horizontal cross-section of a jet stream. The shear flow of cold air from the HIGH troposphere to the neighbouring LOW stratosphere reinforces the geostrophic wind components, while the shear flow of stratospheric air moves in the opposite direction.

frequently confirmed that the maximum wind force lies perpendicular to the point at which the frontal zone is intersected by the 500 mb surface (*fig. 10*). Here the direction and intensity components of the following flows are added together: geostrophic flow (at a maximum at these altitudes, where the slope of the constant pressure surface is at its steepest); downward shear flow of cold air from the HIGH tropopause; upward shear flow of warm air from a frontal zone. Above the jet stream core the temperature on the HIGH side is lower than that on the LOW side. At the level of the jet stream core, which is normally just above the LOW tropopause, temperatures are equal on each side of the maximum wind. Below the jet stream core, in the area of the frontal zone, temperatures on the LOW side are lower than those on the HIGH side.

To sum up, then, the jet stream core is caused by the varying levels of the upper limit (tropopause) of the troposphere, levels which depend on the average temperature of the latter. A steady stream of relatively cold air flows from the marginal zone of a high tropopause to the warmer lower-lying stratosphere, being accelerated on the way down and gradually deflected by the Coriolis force. On reaching its maximum force, it is added to the geostrophic wind, which also has its maximum force at this point, and to the wind on the warm air side of a frontal zone, which moves faster than the geostrophic wind. The gradations in the tropopause which generate the core of the jet stream are due to the fact that the sun warms the earth's atmosphere in different degrees depending on time of year, latitude and distribution of land masses. In the jet stream, jet transport is aided by a natural source of energy whose exploitation is still at its beginnings. ◆◆

Long-Range Jet Aircraft Cruise Performance

By J. F. Renaudie, Technical Director, Ecole du Personnel Navigant d'Essais, Brétigny

On completing his studies at the Ecole Nationale Supérieure de l'Aéronautique in Paris, J. F. Renaudie entered the French Flight Test Centre at Brétigny as an engineer, and played a decisive role in developing and testing civil and military prototypes. In 1957 he became Technical Director of the Ecole du Personnel Navigant d'Essais, which gives pilots and engineers from all over the world special training in test flying. At the Ecole Nationale Supérieure de l'Aéronautique, J. F. Renaudie lectures to future pilots of jet airliners.

In addition to his teaching activities, J. F. Renaudie is the author of numerous scientific publications, including a two-volume work on flight testing, which was published in 1960 by Dunod of Paris. Editors

True or false?

The flight planner and the airline crew operating the fuel-thirsty jet rightly attach great importance to the maximum range of the jet aircraft, or more particularly to the conditions of flight necessary to achieve it.

This problem is by no means new, since it occupied the minds of air force planners long before the advent of the turbojet aircraft into commercial service. It must be admitted, however, that although the solutions are known, they have as yet received scant attention in aeronautical literature.

As a rule, the pilot is generally offered not one solution but two, artistically displayed in theoretical garb. It remains for him to choose between the speeds of 1.19 V_0 and 1.32 V_0 (where V_0 is the speed giving the maximum lift/drag ratio).

Which is right and which is wrong? The mathematical process leading to either one or the other of these two values is correct, but the final choice is left to the pilot. In his turn he abandons the theorists and utilizes the results of practical experiments without attempting to examine them.

Better or the Best?

Reference must first be made to the simple formula expressing the specific range R, the range per unit of fuel, in terms of weight P, specific consumption c (in pounds per pounds of thrust per hour), the speed V and the coefficients of lift C_z and drag C_x.

In a unit of time (an hour for example) the aircraft travels V kilometres, while it consumes a quantity of fuel proportional to the thrust T, namely cT. The range per unit of fuel quantity consumed is therefore:

$$R = \frac{V}{cT} \qquad (1)$$

Expressing T in terms of the two equations of flight, namely, thrust = drag:

$$T = \frac{1}{2}\rho V^2 S C_x \qquad (2)$$

weight=lift:

$$P = \frac{1}{2}\rho V^2 S C_z \qquad (3)$$

gives the equation

$$T = P\frac{C_x}{C_z} \qquad (2a)$$

This expression for T in (1) gives, therefore:

$$R = \frac{V}{c}\frac{1}{P}\cdot\frac{C_z}{C_x} \qquad (4)$$

It is from this equation that the reasoning separates either to 1.19 V_0 or to 1.32 V_0. Taking first the argument which leads to 1.19 V_0, it is desired that R should be maximum. To achieve this it is necessary that the jet engine should be operating under the best possible conditions, which implies cruising speed. The thrust of the engine is therefore defined for each altitude. This constitutes the *fundamental hypothesis for this argument*. The determination of the variation of

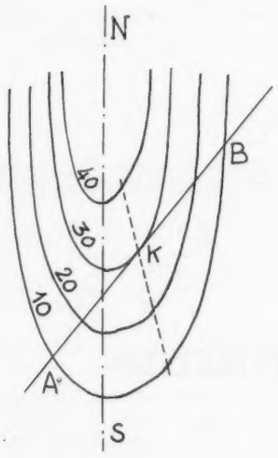


Fig. 1.

thrust with altitude can be made by expressing the thrust T in proportion to ρ, the air density.

$$T = k\rho \qquad (5)$$

Referring to equations (2) and (5), this gives

$$T = k\rho = \frac{1}{2}\rho V^2 S C_x$$

from which $$V = \sqrt{\frac{2k}{S C_x}}$$

Substituting this for V in equation (4) gives

$$R = \frac{k'}{cP}\frac{C_z}{C_x^{3/4}} \qquad (6)$$

k' being a constant $\left(k' = \sqrt{S/2k}\right)$.

Formula (6) enables the following conclusion to be drawn. For the range R to be maximum for a given weight, the ratio $C_z/C_x^{3/4}$ must be maximum. This maximum value corresponds to a particular point on the aerodynamic polar at a defined value of the lift coefficient C_z. Assuming a parabolic curve, this value is $\sqrt{2}\,C_{z_0}$, where C_{z_0} corresponds to the maximum lift/drag ratio. The corresponding indicated airspeed is therefore

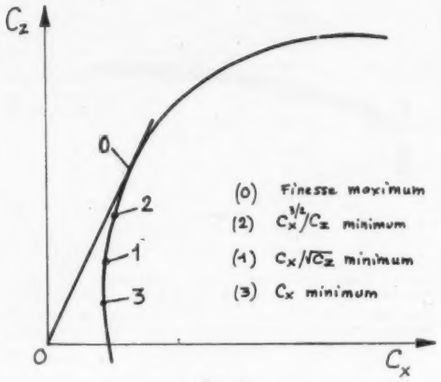


Fig. 2.

$\sqrt[4]{2}\,V_0$ or 1.19 V_0, where V_0 is the indicated airspeed at a particular weight P which gives the maximum lift/drag ratio.

Is this reasoning correct? The answer would appear to be affirmative if the intention is to operate the engine at a particular speed. Is this the aim intended, however? Is it not possible, at the cost of a slight increase in the hourly fuel consumption, to increase the aircraft speed so that the specific range $R=V/cT$ is improved? Furthermore, the fact that the altitude does not appear to figure in the calculation arouses some suspicion. Experience points to the fact that the best range is obtained at high altitudes.

In other words, we have defined the conditions giving the best range for a particular engine speed, but not necessarily the best of all the ranges possible. The restriction imposed at the outset by expressing thrust in relation to air density provides too narrow a scope to enable the optimum figures to be determined.

A geometrical comparison illustrates the type of error that arises. An observer standing a considerable distance to the east wishes to determine exactly the crestline on the north-south axis of a hill. In *fig. 1* the hill is represented by contour lines, and it is required to determine its apparent silhouette as seen by the observer. If the maximum altitude points K are plotted on the contour lines, they fall on the line AB. Although they indicate a maximum altitude line, it is not the crest line desired.

This discrepancy arises from the fact that we are not plotting the altitude points on a curve, but on a surface where the coordinates of each point depend on two variables x and y. In determining an optimum value, it is essential to distinguish between the *variables* and the *parameters*. It is impossible to attach any arbitrary value or variations to the variables, as their values change in relation to the optimum sought.

In the foregoing example, the thrust has been related to the density of the air $T = k\rho$. This involves an arbitrary relationship between the variables of the problem and in consequence introduces an error into the determination of the optimum performance. If the speed of 1.19 V_0 is not necessarily the ideal for the best cruise performance, can it be concluded that the speed of 1.32 V_0 is correct?

Determination of maximum range

We start from the two original equations expressing the conditions of normal horizontal flight where thrust equals drag (2) and lift equals weight (3), but no relationship is introduced between the thrust and the altitude apart from those originating from the performance limits of the engine or aircraft. Also the relationship lift/weight is only limited by the stall characteristics of the aircraft.

To simplify the study, we shall restrict the problem to a consideration of no wind conditions, and an aircraft in which the aerodynamic coefficients are unaffected by the Mach number.

At a later stage, the factors of wind and compressibility will be taken into account.

Zero wind, coefficients of lift and thrust unaffected by compressibility

Commencing with equation (4) stated earlier, instead of introducing a thrust factor in relation to altitude (5), we assume that the aircraft is in lift/weight equilibrium, i.e., that equation (3) is valid. In terms of velocity V, equation (3) becomes

$$V = \sqrt{\frac{2P}{\rho S C_z}} \qquad (3a)$$

giving

$$R = \frac{1}{c}\sqrt{\frac{2}{P\rho S}}\frac{\sqrt{C_z}}{C_x} \qquad (7)$$

In addition to the specific range R, this equation states the following parameters: P = the known weight of the aircraft, c = specific consumption, which is a function of the engine speed

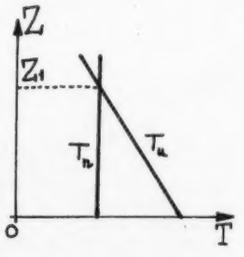


Fig. 3.

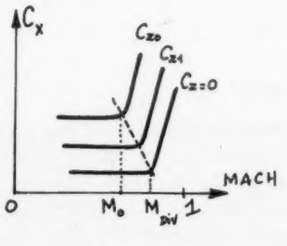


Fig. 4.

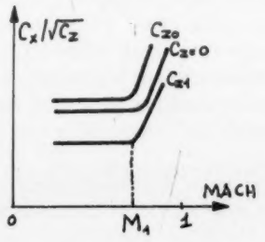


Fig. 5.

and performance limits, ρ = air density which is a function of flight altitude, and the variables C_x and C_z. It is obvious that the ratio $C_x/C_z^{1/2}$ should be minimum to obtain the maximum cruise range.

On the parabolic curve (*fig. 2*), this corresponds to the point at which the lift coefficient $C_{z_1} = C_{z_0}/\sqrt{3} = 0.58\ C_{z_0}$, C_{z_0} being the lift coefficient for the optimum lift/drag ratio. From this the optimum indicated flying speed will be $\sqrt[4]{3}\ V_0 = 1.32\ V_0$, where V_0 is the speed giving the optimum lift/drag ratio.

The speed of 1.32 V_0 is obviously the one which gives the best cruise range, provided that compressibility does not occur. The effects of altitude have also to be taken into consideration, so that the optimum altitude must also be calculated.

From equation (7) it is obvious that the flight should be at the highest altitude possible, the specific range being proportional to $1/\sqrt{\rho}$. Thus at 35,000 ft it is twice as great as at ground level. The altitude is limited, however, by the performance limits of the engine. The minimum value for $C_x/C_z^{1/2}$ gives a constant value for C_z and C_x (independent of flight altitude) and hence for the lift/drag ratio (which is not, however, at its maximum at these values). The required thrust T_n can be calculated from equation (2):

$$T_n = P\frac{C_x}{C_z} = \frac{P}{f}, \text{ where } \frac{C_z}{C_x} = f$$

T_n does not depend on flight altitude; useful thrust T_u, however, decreases as altitude increases. Optimum height Z_1 is therefore attained when $T_u = T_n$ (see *fig. 3*).

The specific range therefore increases in proportion to the value $1/\sqrt{\rho}$ as altitude increases, but only to altitude Z_1. Above Z_1 the pilot must reduce his speed to correspond with the reduction in engine thrust, at the same time increasing the angle of attack to maintain altitude (*fig. 6*).

The conditions for maximum specific range can thus be recapitulated as follows: Altitude Z_1; flight speed 1.32 V_0; and an angle corresponding to a minimum of $C_x/C_z^{1/2}$. As however, 1.32 V_0 represents a constant indicated airspeed, the corresponding *true* airspeed increases with altitude (see *fig. 6* right) and can at times come so near to sonic speed that our assumption—the independence of aerodynamic coefficients from Mach number—is no longer valid.

Zero wind, compressibility of air considered

Above a certain Mach number the drag coefficient rises sharply; the higher the lift coefficient C_z, the lower this Mach number will be (see *fig. 4*). The expression *critical Mach number* (M_{div}) is used by aircraft designers with reference to the minimum drag coefficient; the critical Mach number is thus the speed at which this sharp drag rise occurs. The result of the dip in drag coefficient curve is that the term $C_x/\sqrt{C_z}$, whose minimum is of decisive importance for maximum range, begins to increase from a certain Mach number which lies below the critical (see *fig. 5*).

Here two separate cases can be distinguished: 1) Mach number M_1 lies above the flight Mach number appropriate to flight altitude Z_1. In this case the above situation applies. 2) Mach number M_1 is reached at a lower altitude than Z_1. Here the optimum flight altitude for a given range is determined not by the engine, but by the sudden drag rise at Mach number M_1 (see *fig. 7*: optimum altitude = Z_1).

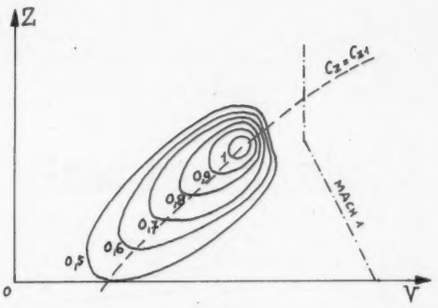


Fig. 9.

Cruising with continuous climb

This procedure is generally desirable for long-range transport, but is practicable only up to a certain degree, for air traffic control reasons. It is easy to see that the conditions of *constant Mach number* and *constant lift coefficient* must inevitably lead to continuous climb. If in the equation for dynamic pressure, speed V is expressed by Mach number, we have:

$$q = 0{,}7pM^2$$

where p indicates static air pressure. From the lift equation (3) we have

$$P = 0{,}7pM^2SC_z \text{ and hence}$$

$$\frac{P}{Sp} = 0{,}7C_zM^2.$$

If C_z and M are to remain constant, P/Sp must also remain unchanged. In other words, air pressure must decrease in the same proportion as weight during flight—resulting in a continuous climb. In order to fulfil these conditions, the pilot needs an angle of attack indicator and a Machmeter.

Variable specific fuel consumption

As shown in *fig. 3*, the two values T_n (required thrust) and T_u (useful thrust) tend to coincide as altitude increases, until the engine delivers maximum thrust at altitude Z_1. Consequently, specific fuel consumption c also varies, generally reaching its minimum at 80/90 percent of maximum thrust. *Figs. 6* and *7* are thus slightly modified. The optimum flight altitude Z_1'' generally lies a little below Z_1' (see *fig. 8*).

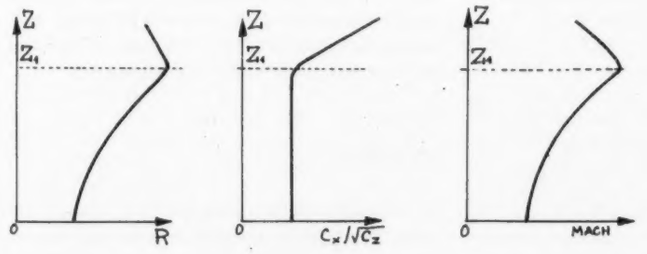


Fig. 6.

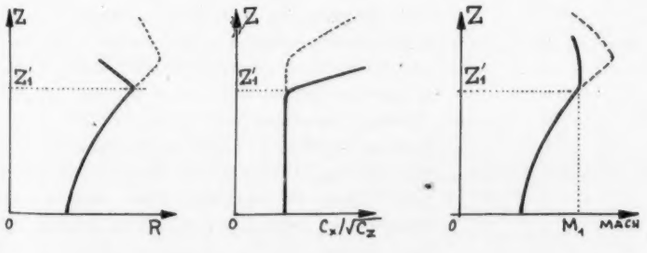


Fig. 7.

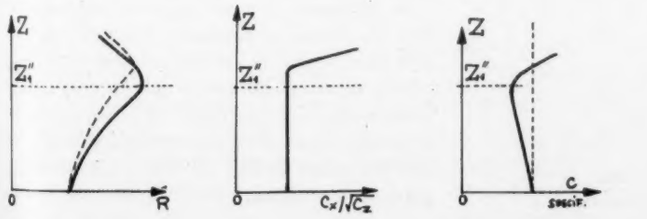


Fig. 8.

These examples show that in each case there are a given angle of attack and a given Mach number at which maximum range can be achieved in still air. Thus for a given aircraft weight, speed and flight altitude are also fixed. In the speed/height graph, *curves for the same range* can be

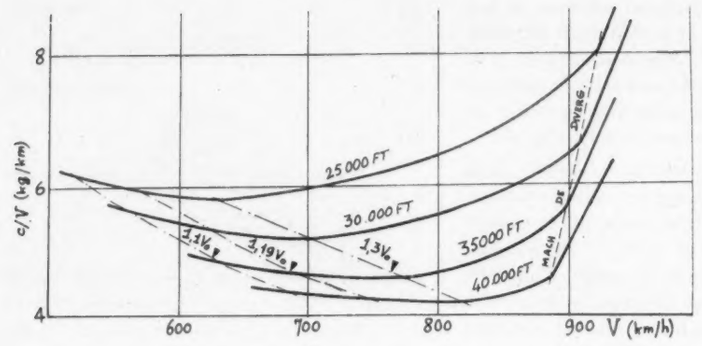


Fig. 10.

drawn; these look like the contour lines of a mountain at subsonic speeds (see *fig. 9*; the figures next to the "contour lines" give the attainable range as a fraction of maximum range). In addition, the graph shows that it is better to fall short of optimum speed and optimum altitude than to exceed them.

Theory and practice

Let us now compare theory with practical experience. *Fig. 10* shows the curves for a version of the Douglas DC-8 with an all-up weight of 63½ tons. The curves show fuel consumption in kilogrammes per kilometre as a function of flight speeds at different altitudes (pressure altitudes of 25,000 ft, 30,000 ft etc.). It will be seen that each of these curves has its minimum at 1.32 V_0, in accordance with the second argument. It will also be seen that the curves are very flat and that fuel consumption is almost as low at the speed 1.19 V_0, in accordance with the first argument. The higher speed does, however, offer the decisive advantage of shorter flight time.

As the curves are so flat, one to two percent of range can be sacrificed to obtain a seven to eight percent reduction in flight time by flying at a higher speed, say 1.4 V_0. As will be seen later, this is particularly desirable where there is a head wind. In addition, the Mach number corresponding to the indicated speed 1.32 V_0 (or 1.4 V_0) increases with altitude, so that above a certain flight altitude the onset of shockwaves reduces the optimum speed.

These conditions are shown in a slightly different form in *fig. 11*. The solid curve indicates fuel consumption per hour for a large jet airliner as a function of flight Mach number, at a constant flight altitude of 30,000 ft. The dotted curves are calculated and do not take account of air compressibility. There is a distinct difference between the optimum Mach number M_1 and the critical Mach number M_{div}. As already mentioned, the critical Mach number corresponds to the lift coefficient C_z, which is part of the minimum drag coefficient C_x min and is quite separate from the lift coefficient required at this altitude.

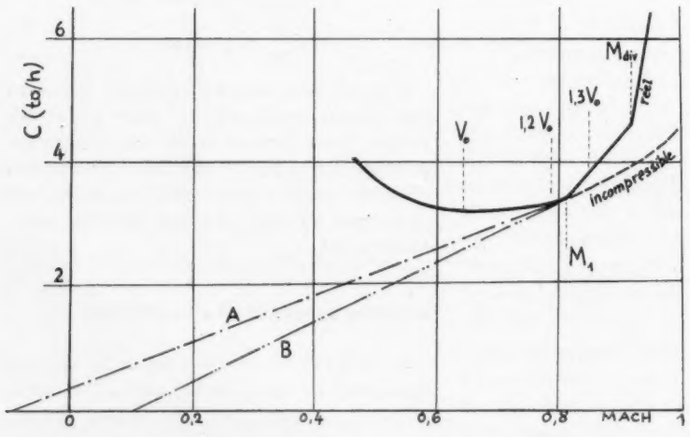


Fig. 11.

In order to find the flight Mach number resulting in the lowest fuel consumption per unit of distance, i.e., in the maximum range, let us draw a tangent from the origin of the graph (point 0) to the curve. The abscissa at the point of contact indicates the required Mach number in still air. In *fig. 11*, however, allowance can also be made for wind. To obtain maximum range, the ratio of ground speed to fuel consumption per hour must also be as high as possible. With a tail wind, therefore, the tangent is drawn not from the point of origin 0, but from a point to the left of it (straight line *A*), the distance of this point from the origin 0 corresponding to the wind component in the direction of flight (expressed as a Mach number). In the case of a head wind the tangent is, of course, drawn from a point to the right of the point of origin (straight line *B*).

As the solid curve changes direction sharply at M_1, the point of contact of the tangent will either coincide with the angle or lie somewhere near it. From this it will be seen that the wind has little or no effect on fast jet aircraft flying under optimum conditions (Mach number, angle of attack, etc.). This does not apply to slow aircraft.

If we plot the required thrust against the flight Mach number, it will be seen that the curve obtained will be very flat below M_1, and steep above M_1. This means that there is little alteration in flight speed if engine thrust lies slightly above that required for optimum range, but that a thrust slightly below the optimum will lead to an appreciable reduction in flight speeds.

Conclusions

Although the first solution—1.19 V_0—is not exact, neither is it completely wrong, as the exact solution—1.32 V_0—loses its validity at high altitudes owing to the sharp rise in shockwave intensity. In principle, a *constant Mach number and a constant angle of attack* are necessary to obtain maximum range, together with a constant flight altitude and a constant speed. As weight is reduced in the course of flight, there is an optimum flight profile, as shown in *fig. 12* for a Boeing 707 on the New York-Los Angeles route. Here the optimum flight path (solid straight line) is usually replaced by a series of steps (dotted line), as continuous climb is impracticable for air traffic control reasons.

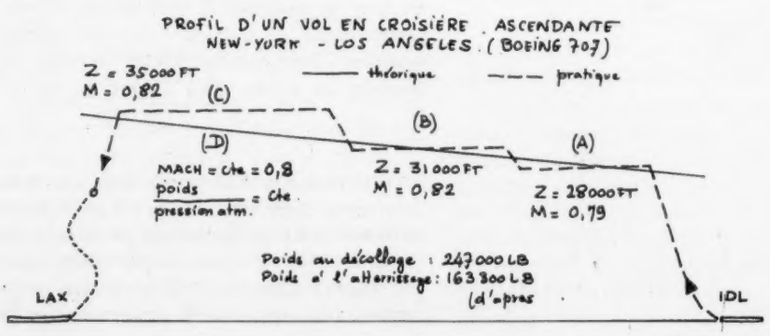


Fig. 12.

In conclusion it should again be emphasized that the foregoing arguments apply purely to long block distances, where the initial and final phases of each flight—climb and descent—play a secondary role. The shorter the block distance, the greater is the effect of climb and descent, so that the optimum flight altitude is considerably lower on short stages than on longer routes. ◆◆

The Answer to the Puzzling Riddle:

"What Makes an Airline Profitable?"

By Richard W. Klabzuba, Austin, Texas

Since the advent of the jet airliner, creakings and groanings have been heard in the beams of the already none too sound air fare edifice. The growing numbers of new aircraft types which are entering service are showing up to an increasing extent the differences in comfort and speed between jets and propeller-driven aircraft, to the disadvantage of companies which for lack of means are obliged to continue operating the latter—charging the same fares on the same routes. All those concerned are fully aware that a vigorous reform of the fare structure must shatter the foundations of the present air transport economy. Many bitter battles are fought before even minor fare adjustments receive the approval of all the organizations concerned. There is no lack of proposals to improve this state of affairs, but an ideal solution—always assuming that one exists—is still a long way off.

Although it does not entirely coincide with their views, the editors welcome this opportunity to print the following article, which deals with the situation of American domestic traffic. Ed.

What makes an airline profitable? In the jet age the destiny of an air carrier depends upon a correct answer to this question. The solution, however, is made elusive and perplexing because of the intangible nature of air transportation.

Since most of the air carriers which appear to have found the formula for profitable operations have usually been among the larger organizations, it has generally been assumed that the economics of size controls an airline's success. The very nature of the airline business, with its apparent tendencies toward lower costs with large scale operation, would seem to indicate that the economics of size should be of tremendous significance. But the large amount of evidence available from many individual airline operations has tended to disprove this contention.

There has been little if any correlation between the size of an air carrier and its total operating expense per flight hour, particularly regarding its direct operating costs. The data concerning maintenance expense provide no particular evidence that an increase in the size of a carrier will automatically be accompanied by any pronounced expense reduction. And the tendency of certain indirect operating costs, especially the ground handling expense, to decrease with size actually may be due more to the traffic density of carriers rather than their size.

This lack of any difference between the operating cost of the large carrier and the smaller carrier necessarily leads one to the belief that there is some important factor other than size which determines the profitability of an airline.

Airline fares in the United States generally are calculated on the basis of a certain amount per mile, with the mileage being calculated through all certificated points. There are numerous deviations both from the mileage calculation and the rate per mile, and naturally the mileage of the carrier having the shortest route sets the fare, the other carriers meeting this tariff.

To the basic fare structure, which was developed during World War II, there has been imposed a terminal charge of $2.00. Also a series of promotional discounts and special fares have been initiated from time to time. But in general the rate structure has resulted in fares becoming a function of mileage.

Traffic statistics consequently have also continued to be gathered on a mileage basis. This is in spite of the fact that in aviation the lack of a physical route has forced the arbitrary adoption of the estimated flight path traversed, for measuring distance.

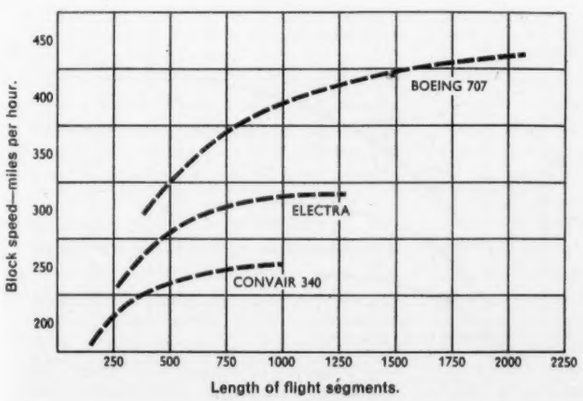
Certain practical significance may be attached to each of the several different paths, but their values are of minor importance since one fallacy exists—costs are not a function of mileage. In fact none of the costs of producing the product are related to miles traversed; the overwhelming evidence is that the majority of costs are constant with an entirely different unit—the number of hours flown.

The direct operating cost, for example, which is formed of such items as fuel consumed, maintenance, and crew salaries, is completely determined by the number of hours flown. Even two items which are shown in the Air Transport Association 1955 formula as being computed on the basis of mileage are frequently manipulated so that they are actually calculated on an hourly flight basis. Accordingly, operation and engineering statistics were long ago established on this basis, and since then hours and minutes have proven to be accurate and complete measuring units. Thus management is required to compare traffic data computed by mileage with operating data which are determined by an entirely different unit —the number of hours flown.

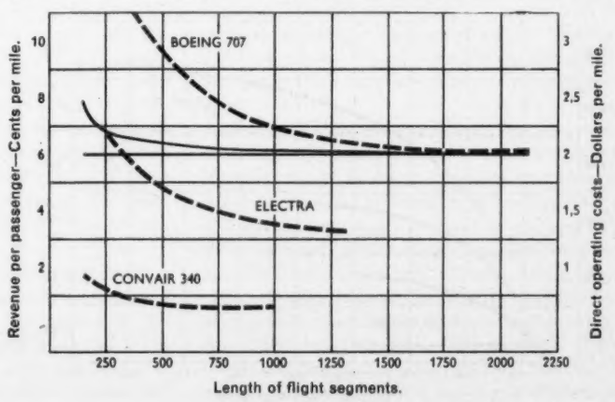
Distance has been defined as the measurement of the path which must be traversed in passing from one point to another. According to Albert Einstein, distance is relative. In mathematics the term "distance function" is used to refer to any suitable operation which may be used to give a numerical measure to the separation of two entities. Therefore the indication that the total costs of an air carrier are a coefficient of a flight hour would appear to indicate time as being the most accurate unit available. Further, the fact that length and velocity are both factors of time certainly makes it a more complete unit.

To repeat the definition—distance is the measurement of the path which must be traversed in passing from one point to another, so that the distance may be

A comparison of the block speeds of three types of transport aircraft, relative to the length of the flight segments.



Revenue per passenger in cents per mile (left side) and direct operating costs in dollars per mile (right side) shown relative to the length of flight segment. The straight line indicates revenue at six cents per mile, while the curved unbroken line represents the revenue at 6 cents per mile plus the addition of $2 to each fare.



recorded in either length or time. The term may also be used to refer to the separation in time of two events. However, to avoid confusion with time as a chronological measurement, a new term should be assigned which will mean only distance measured in hours and minutes.

In flight, all measurements become relative since one body is travelling through another body which may or may not be moving. As a result, there are many relative measures in aviation. Today some of these are widely used and have been commonly identified as true air speed, true heading, true course, etc. Therefore, since time is the true measurement of distance between any two points for a given body, the ideal term for distance measured in hours and minutes would be "true distance." Further, since "true distance" is a new term, certain rules have had to be established to govern its use. And finally, since these rules must apply in all cases, they have become known as the Law of Distance: "The true distance between any two points for a given body is the least time required to move that body between the two points."

It is generally accepted that the profitability or economic justification of any business is dependent upon income exceeding costs. Accordingly, since airline operating costs are a coefficient of a flight hour, the ability of any airline to make a profit is dependent upon its level of revenues received per flight hour being greater than its total operating expense per flight hour.

The actual problem of achieving a profitable airline operation is slightly more complex, for most airline revenue is derived principally from the sale of individual seats to passengers or pounds to shippers, although the amount of expense is determined by the aircraft, which is an aggregate unit. The expense of operating the aircraft is approximately the same whether the available capacity is or is not utilized, so that the economic profitability of an airline is not governed by a difference between the selling price and cost of producing an individual seat or ton. Instead, the profitability of an airline operation is determined by the number of individual passengers or pounds which are generated and the established rate level per flight hour in relation to the total cost of producing the aggregate unit, including the expense of processing each passenger or shipment.

Because profitability depends upon the number of seats or pounds sold relative to the break-even load factor, the critical ratio in air transportation is the load factor ratio. This is a ratio of the actual load factor attained to the break-even load factor required. The load factor ratio is the reciprocal of the operating ratio, but is more useful in aviation because it can only be used with an aggregate unit and has the additional advantage of showing positive changes through an increase.

Many factors are significant in the operation of an airline but these factors are only functions of the load factor ratio. For example, the utilization and configuration of an aircraft and the level of rates establish the position of the break-even load factor. The density of traffic, the character and quality of service and the effectiveness of marketing determine the actual load factor attained. Clearly then, the objective of any intelligent airline management is to increase the load factor ratio by minimizing the break-even requirement and maximizing the actual load carried on each individual flight.

The break-even load factor, however, has been defined as that percentage of revenue utilization of capacity which will just pay for all the expenses of an operation. Therefore, the break-even load factor depends not only upon the level of expense but also the rate level at which the capacity is sold. If the level of the rate is high, a fewer number of revenue passengers or pounds will be required to meet all expenses (and the break-even load factor will be lower) than if the rate level were reduced.

Should the individual fares be computed by mileage and the operational cost of the aggregate unit vary with the number of hours flown, as in aviation, then the block speed becomes a very significant factor in determining the break-even load factor. In such a case, any increase in velocity will decrease the break-even load factor simultaneously. This results from the proportionate increase in the revenue per hour or decline in the cost per mile.

The graphic presentation of speed, cost and revenue usually has been on a mileage basis, as shown in Charts 1 and 2. The block speed is displayed as increasing with range while the cost per mile decreases. Because the revenue is held relatively constant per mile, the profitability of flight would increase with range also. Nothing appears abnormal, since costs are expected to decrease with range. This theory was recognized officially when the Civil Aeronautics Board permitted the domestic carriers of the United States to add a flat amount to each fare.

However, when these same data are compiled on an hourly or true distance basis, as they would be in the operations department, an entirely different picture is presented. In Chart 3 the variable block speed of the aircraft is now depicted as effecting an increase in the level of the rates. It should be noted that cost levels indicated in Charts 1, 2 and 3 were calculated with the 1955 ATA formula, which does not consider all the costs associated with landing and take-off. It is generally recognized that fewer landings and take-offs per flight hour will result in a lower direct operating cost, so that the true pattern of the direct operating costs, if they could be calculated exactly, would probably be to decrease with range as shown in Chart 4. Thus graphically is displayed the strange phenomenon of the present airline fare structure in the United States, wherein as costs decrease the price is increased, and as costs increase the price is decreased.

The consequences of the airline fare structure being computed on a length basis are many and diverse. A long-haul service, for example, is more lucrative not because it is in greater demand and can be produced at a lower cost per hour, but rather because its level of rates is so much higher. Of course the higher rate level shrinks the market, but under this type of fare structure a carrier is helpless to reduce the fare, since this would also require a proportionate reduction in the medium and short-haul fares. Special fares can be introduced, but this is frequently undesirable and can even produce discrimination.

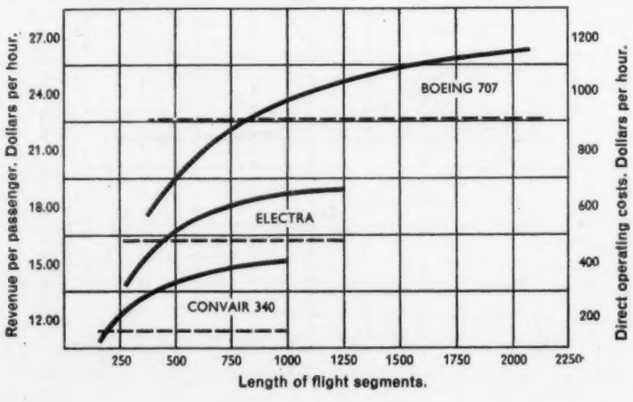
But the real impact of this fare structure is on the medium- and short-haul service. Traffic between most stations is insufficient to justify non-stop service, and therefore in an attempt to obtain better utilization of the available space, many services are provided via one or more intermediate points. This in turn necessitates many additional landings and take-offs which reduce the block speed of the aircraft and decrease the level of the rate per hour. The reduction in the rate level curtails the monetary value of each unit carried.

The increase in flight time of course raises the expense of providing the service. As a result, the break-even load for a short-haul service is very high, and this is the primary reason why the local service carriers are unable to become self-sufficient.

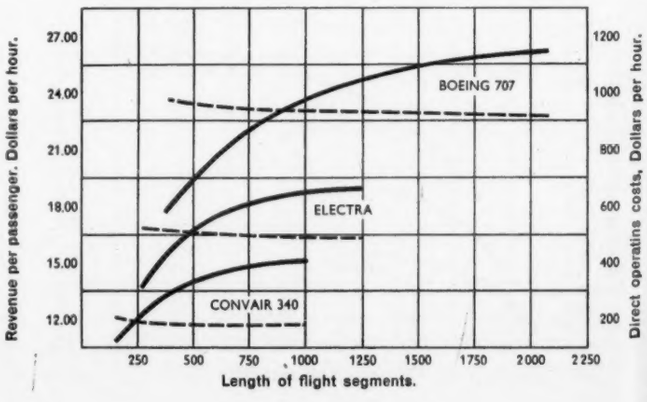
A medium-haul example of this situation is outlined in Table 2, for two services between Oklahoma City and New York which were potentially available in June 1958. Although a penetrating examination would reveal many interesting details, it is sufficient for the purpose of this discussion to merely bring forth the fact that the fare structure forced the carrier to charge less for a service which cost it 9 to 24 percent more to produce (Flight AA38 was at that time the fastest service available at the fare of $89.50).

The combination of these three disadvantages (a low rate level, an increased operating cost, and a high break-even load factor) would in themselves be sufficient to make the medium- and short-haul services less desirable, but unfortunately the computation of fare on any length basis produces an associate problem which causes an even larger operating expense and

The revenue and operating costs of the three aircraft compared on a time basis. The unbroken lines indicate revenue per passenger in dollars per hour (left hand scale) while the direct operating costs are shown by the broken lines (right hand scale). The base line denotes the length of flight segments.



The same pattern of passenger revenue and direct operating costs as displayed in Chart 3. In this example, the operating costs have been adjusted to illustrate the reduction which occurs with fewer landings and take-offs per flight hour.



also leads to a reduction in the load carried on many flights.

The shortest practicable route between any two points is the true distance path. For aviation this is always the least expensive and fastest route. In the Oklahoma City to New York example, this path passes through Dallas. Under the true distance system this routing is not only permissible but encouraged as the most desirable routing. Under the length system, however, this routing is not permitted.

The linear nature of length includes a directional characteristic. This characteristic has been interpreted to mean that a route shall not pass through any point which is physically on a map behind or beyond the terminals. The theory is that the passenger would be getting something for nothing. This does not mean the passenger cannot travel more miles, more miles than even the path of the true distance route, it just means that the physical location of an intermediate point on a map cannot be beyond the two terminals. Therefore, since Dallas is 41 miles further away from New York than Oklahoma City, this routing is not permissible.

A fare structure computed on a length basis consequently makes it mandatory that routes be established and flights operate via a direct length path. However, since the least expensive and fastest route always follows the true distance path, this requirement automatically increases operating cost in five ways:

1. An increase in flight time because the least length path must be followed;

2. An increase in flight time due to the additional flights which must be offered to provide sufficient service via the least length routes;

3. An increase in flight time resulting from the multiple-stop operation necessitated by insufficient traffic on many of the least length routes;

4. An increase in the level of the direct operating cost caused by the greater number of landings and take-offs per flight hour associated with the multiple-stop services;

5. An increase in the operating cost level because of the expanded need for flight equipment resulting from low utilization and providing of additional services.

This combination of more service, provided at a higher cost level, over a longer path, when computed with the lower rate level resulting from the slower speed, naturally creates a still higher break-even load factor.

The reduction in the load carried on many flights is due first to the inferior quality of many local services. The principal marketing feature of an airline is speed. Speed to the customer is not just the flight time, but rather the elapsed time and frequency too. The length system, however, frequently increases the flight time, necessitates more ground time at en-route stops and reduces the potential frequencies by requiring directional movement. Thus the advantage of speed often disappears. This problem is more acute for the short-haul carriers because their traffic originates principally in the expense account market, and it is the business man who places the greatest value on time.

The second and probably the most uneconomical effect of the length system on aviation is the diversion of traffic. The length system with its linear characteristic necessitates the potential traffic being routed via a direct length path, and thus often diverts this traffic from a lower cost and faster true distance route. This diversion, moreover, spreads the potential traffic over more flights and flight hours, thereby reducing the profitability of some service while frequently failing to provide sufficient traffic to meet the break-even requirement of additional short- and medium-haul services. Finally, this fare structure also results in the undesirable use of long-haul traffic to support local services.

Table 1

Direct Flight Cost Per Total Hour and Total Assets By Aircraft Types, Year ended December 31st, 1958

Total Assets (000) (as of June 30th, 1958)		Total Maintenance Cost Per Total Hour		Total Flight Cost Per Total Hour		Total Hours Flown	
	$	**DC-6 B**			$		
American	418,513	Eastern	54.21	National	257.46	United	99,654
United	391,153	Western	61.52	American	267.48	American	62,101
Eastern	284,823	Northwest	72.08	Western	273.86	Western	54,329
Northwest	115,454	Northeast	78.30	Northeast	279.06	Northwest	32,326
National	77,097	National	81.50	United	292.41	Northeast	36,196
Western	54.424	United	85.89	Northwest	307.18	National	22,559
Northeast	36,009	American	97.05	Eastern	328.02	Eastern	14,690
		Convair CV-340					
United	391,153	Braniff	49.07	Braniff	165.32	United	99,734
Eastern	284,823	Eastern	52.92	Eastern	175.21	Braniff	84,989
Delta	101,706	Delta	53.74	Delta	179.10	Delta	71,041
National	77,097	National	63.25	National	189.67	Eastern	55 484
Continental	71,133	United	63.96	Continental	195.31	National	40,768
Braniff	67 734	Continental	66.96	United	203.84	Continental	20,202
		DC-3					
Northwest	115,454	West Coast	22.84	West Coast	81.82	North Central	80,430
Delta	101,703	Braniff	26.17	Pacific	81.90	Piedmont	53,082
Capital	84,300	Ozark	26.50	Braniff	83.52	Ozark	45,702
Continental	71,133	Northwest	27.08	Capital	85.21	Capital	41,898
Braniff	67,734	Continental	27.94	Northwest	85.87	Frontier	41,845
Northeast	36.009	North Central	28.70	North Central	86.81	Braniff	40,565
Piedmont	10,946	Lake Central	28.83	Piedmont	87.95	Trans-Texas	39,518
Pacific	8,737	Capital	30.05	Trans-Texas	88.79	Allegheny	31,533
North Central	8,559	Piedmont	30.72	Lake Central	89.64	Continental	29,750
Pacific Northern	7,756	Trans-Texas	32.24	Delta	90.13	Southern	28,173
Mohawk	7,190	Allegheny	32.26	Central	91.07	West Coast	28,096
Hawaiian	7,177	Central	32.39	Bonanza	91.28	Bonanza	27,114
West Coast	7,146	Frontier	32.43	Southern	92.39	Northeast	26,653
Frontier	5.874	Southern	33.46	Frontier	92.72	Central	26,434
Bonanza	5,645	Delta	33.59	Ozark	92.79	Lake Central	22.098
Allegheny	5,507	Ozark	33.09	Allegheny	95.39	Delta	22,778
Aloha	4,212	Bonanza	33.73	Northeast	97.16	Pacific	19,279
Ozark	3,644	Mohawk	34.11	Continental	98.93	Mohawk	16,300
Trans-Texas	3,523	Aloha	34.21	Mohawk	101.43	Aloha	11,026
Southern	2,576	Hawaiian	38.93	Aloha	103.88	Hawaiian	10 145
Central	1,854	Pacific Northern	39.25	Hawaiian	106.89	Northwest	9,393
Lake Central	1,693	Northeast	41.44	Pacific Northern	112.97	Pacific Northern	5,001

Source: CAB Direct Flight Cost per Total Hour by Aircraft Types, Year ended December 31st, 1958.
CAB Quarterly Report of Air Carrier Financial Statistics, June, 1959.

Of course the introduction of a non-stop flight, such as between Oklahoma City and New York City, could change the true distance. The traffic potential at present, however, is insufficient to make such service economically practical, and what is being considered is the shortest practical route. But even should such a non-stop flight be instituted, the next most desirable service for both the carrier and the customer would still be via Dallas.

Although many carriers have long since abandoned any pretense of establishing their fares in relation to a basic rate per mile, every airline and government aviation agency has continued to maintain its traffic statistics on a length basis. This has necessitated each carrier developing simultaneously two statistical systems, one on an hourly (true distance) basis for operations, the other on a mileage or kilometer basis for traffic. Both systems are therefore proven. The difference between the systems is velocity, a factor which has become pronounced in recent years due to the improved performance of modern aircraft.

The question then naturally arises as to which of the systems is more accurate. Moreover, should one of the systems possibly be converted? What is being considered therefore is not a radical change, but rather a modification which would result in one common statistical system.

It has been repeatedly pointed out that the true distance (hourly) basis is the more complete, the more accurate measuring unit. For this reason it was adopted by operating and engineering personnel. The "plane-mile" unfortunately is a static unit and thus unable to accurately record a dynamic situation. As a consequence, data which have been presented on this basis have frequently been very inaccurate, since they were composed of averages of averages, or averages of arbitrary amounts.

The average cost per mile, for example, is an average composed of two other averages: the average cost per hour and the average block speed.

The cost per hour must be computed before cost per mile can be calculated. Further, any operating cost shown for a specific length is valid only if the block speed remains the same. The length system, therefore, can not show local differences. When arbitary mileage is utilized, such as in the "Airline Traffic Survey," the length recorded for a haul often represents a substantial departure from the passenger miles actually traversed.

Thus the accurate cost statistics of operations have been buried under a maze of traffic statistics which are computed with arbitrary mileage and secondary averages. The conflict between the two systems has been accentuated by the introduction of many new high-performance aircraft, especially the turbojet and turboprop which have very great variations in block speed.

Nevertheless the requirement for accurate statistical data has become imperative with the advent of government and industry regulations and controls. The measuring unit and formula which is adopted as a standard must be able to make an accurate comparison of every type of operation. The only unit which will meet all the specifications is true distance.

True distance possesses the unique characteristic of automatically assimilating all the intangible properties in a dynamic situation. This important ability to measure exactly the actual distance traversed in moving between two points makes true distance the

Table 2
Comparison of Distance and Elapsed Time Between Oklahoma City and New York, July 1st, 1958

	Flight Schedule and Total Elapsed Time	Distance	
		Length in Miles	True Distance in Hours
Route A (AA Flight 38 : DC-7)			
Oklahoma City C.S.T.	dep. 15 : 15	111	0 : 40
Tulsa "	arr. 15 : 55		
" "	dep. 16 : 25	515	1 : 55
Nashville "	arr. 18 : 20		
" "	dep. 18 : 45	562	2 : 00
Washington E.D.T.	arr. 22 : 45		
" "	dep. 23 : 05	215	1 : 05
New York "	arr. 00 : 10		
Totals Route A	6 : 55	1,403	5 : 40
Route B (AA Flight 17 : DC-7)			
Oklahoma City C.S.T.	dep. 07 : 55	181	0 : 50
Dallas "	arr. 08 : 45		
(AA Flight 84 : DC-7)			
Dallas C.S.T.	dep. 09 : 15	1,381	4 : 35
New York E.D.T.	arr. 15 : 50		
Totals Route B	5 : 55	1,562	5 : 25
Route B vs. Route A	—1 : 00	+ 159	—0 : 15

Table 2 A
Comparison of Direct Operating Cost on Routes A & B to New York at $437.25 per DC-7 Flight Hour

	Scheduled Flight Hours	Direct Operating Cost Per Trip
Route A	5 : 40	$2,477.46
Route B	5 : 25	2,368.15
Saving via Route B	0 : 15	$ 109.31

Table 2 B
Comparison of Direct Operating Cost and First Class Fares on Routes A & B to New York from Various Cities

	Distance		Direct Operating Cost		First Class Fare	
	Length in Miles	True Distance in Hours	Per Trip	% of Dallas/ New York rate	Tariff	% of Dallas/ New York rate
Dallas	1,381	4 : 35	$1,987.92	....	$93.60	....
Oklahoma City (via Tulsa)	1,341	5 : 40	$2,477.46	+23%	$89.50	— 4%
Tulsa	1,231	5 : 00	$2,186.25	+ 9%	$82.35	—12%

Sources: Official Airline Guide, July 1958.
CAB Mileage Book No. 1 (based upon)
CAB Direct Cost per Total Hour by Aircraft Types, Year Ended December 31st, 1958.

ideal unit in aviation for both operations and traffic. It is a mandatory tool in operations research. A problem whose factors would require that a carrier operate its flights so they flew the least number of miles (length) and the least number of hours (true distance) could easily result in a frustrated computer.

The introduction of a common system to replace the present dual set of complex data could result in top management being able to more efficiently employ the resources available. Statistics prepared by the true distance method might enable a carrier's management to recognize problem areas sooner. The system certainly would result in rates being established more precisely.

There are two methods by which distance may be measured. The system based on length utilizes miles, kilometers, etc., while true distance is measured in hours and minutes. The intangibility of the actual flight path plus the increasing variability in block speed of modern aircraft has reduced the value of length. Engineers, however, quickly recognized the accuracy of true distance and adopted flight hours as the measuring unit for aircraft operations. The simultaneous development of two statistical systems followed.

As long as there was only a small variation in block speed and one type of aircraft operated, as the DC-3, harmony between the systems was not disturbed. Nevertheless, the constant introduction of new aircraft with improved block speeds destroyed, piece by piece, the compatibility of the two systems, the introduction of the turbojet merely sounding the death knell.

The inconsistencies between the two systems are difficult to recognize because of the difference in the unit which they measure. The traffic statistics, based on mileage, record individual passengers, seats or pounds, but the statistics based on the hourly unit utilized by operations are compiled for the aircraft, which is an aggregate unit.

In any case, since the total cost of operating aircraft is relatively constant per hour, profit depends on the total revenue per hour exceeding the total cost per hour. If efficiency means producing a product for the lowest possible cost, then for an airline this would be synonymous with completing a trip in the shortest flight time. The problem in aviation is therefore not how to traverse the least number of miles between two points, but rather the least number of hours.

Profitability depends upon traffic too, so that the shortest practical route between two points is the shortest true distance route with sufficient traffic potential.

The continued use of miles and kilometers to establish fares has had a profound effect upon air transportation in the United States and other nations in varying degrees. For the carriers, the fare structure based on length has resulted in:

1. Reduced markets due to the higher level of rates necessitated by the operation of many inefficient and uneconomical services, and the higher fare which must be charged on the long-haul services;

2. Reduced load on many flights because of the diversion of the traffic to other services, in addition to reduction in the potential market;

3. Low utilization of flight equipment associated with many multiple-stop operations, plus the need for additional equipment to perform minimum short-haul service patterns;

4. Increased need for capital to purchase the additional flight equipment necessitated by low utilization;

5. Conflicting statistics caused by the development of two systems and the introduction of modern high-performance aircraft;

6. Reduced yield on capital resulting from

   a) increased flight time required to complete a trip via least number of miles;

   b) higher operating cost associated with multiple-stop flights;

   c) utilization of long-haul traffic to support short-haul services; and

   d) increased overheads necessary to provide the additional minimum services.

The reduced yield naturally has reduced the return on investment to the stockholder. This fare structure also is the primary cause for the violent earning fluctuation which has become a historical characteristic of the airline industry.

Because the length fare structure results in a very high break-even load factor for short-haul operations, the Civil Aeronautics Board is faced with the possibility of permanent dependence of local service carriers on government subsistence under this system. However, the Congress of the United States declared it to be the policy of the Board to "... recognize and preserve the inherent advantage ... (and) ... the promotion of (an) adequate, economical, and efficient service by air carriers at reasonable charges." The inherent characteristic of an airplane is an operating cost which varies with the number of hours flown, and the most economical and efficient path for an airline is the true distance route.

And last, but not least of all, the length fare structure has frequently provided the customer with an inferior product in the form of increased travel time both in the air and on the ground, more multiple-stop services, and fewer frequencies. This product of course has been provided at a higher fare because of the higher level of rates necessitated by many inefficient and uneconomical services.

Tapered and special fares have been tried, but have not solved this problem because they are only a modification of the length fare structure. They are unable to provide the multiple routes or cure the problem of inconsistency in statistics. There is one, and only one, solution for the basic problem—that is an airline true distance.

Question: What makes an airline profitable?

Answer: An airline can be profitable only if its total revenue per unit of true distance exceeds its total operating cost per unit of true distance. ◆◆

BRITISH AIRCRAFT CORPORATION

The new force in world aviation

The four member companies of British Aircraft Corporation have, since the war, constructed over 5,000 aircraft of all types. This number includes: **500 Four-engined Turbine Airliners, 900 Twin and Four Jet Bombers, 1,700 Jet Fighters, 1,100 Trainers.** The Aircraft now being built or developed within British Aircraft Corporation include VC10, Super VC10 and BAC-107 rear-engined jetliners, Vanguard and Viscount turbo-prop airliners, Canberra jet bombers, Lightning and TSR-2 supersonic military aircraft, the Jet Provost trainer, the T-188 all-steel supersonic research aircraft and a project study for a supersonic airliner* Guided weapons produced by British Aircraft Corporation include Bloodhound, Thunderbird, Blue Water and Vigilant* British Aircraft Corporation combines the aircraft and guided weapons interests of:

Bristol Aircraft Limited · English Electric Aviation Limited
Vickers-Armstrongs (Aircraft) Limited · Hunting Aircraft Limited

Together these famous companies have fashioned a powerful new force in world aviation. It is backed by great resources and by a confidence, an experience, and a knowledge unique to an organisation whose aircraft are today in service with 50 airlines and with the armed services of 28 nations.

TSR2 ...ordered for The Royal Air Force

During a recent speech, Britain's Minister of Defence, Mr. Harold Watkinson, said of TSR2 . . .

- **STOL**
- **Long range at Mach 2 or better**
- **Wide range of weapons**
- **Great flexibility of roles**
- **High accuracy navigation/attack system**

'One of the principal features of TSR 2 will be its ability to operate at high speeds and at extremely low altitudes .... an automatic terrain following device will enable the aircraft to approach its target beneath enemy radar cover. It should be practically invulnerable to all known forms of counter-attack .... As far as is known, this low altitude performance is not matched by any other aircraft in the world at the present time.'

TSR 2

Powered by Bristol-Siddeley Olympus Turbo-jets.

BRITISH AIRCRAFT CORPORATION

ONE HUNDRED PALL MALL LONDON SW1 ENGLAND

BLOODHOUND PROVIDES EFFECTIVE DEFENCE

Bloodhound is a very high performance guided weapon system which has been designed to counter both high and low level attack. It can form part of an integrated defence and can intercept and destroy any known manned aircraft in service.

Bloodhound is launched by solid-fuel boost rockets and when the missile reaches supersonic speed the main power-plants, two Bristol Siddeley Thor ramjets, take over. The ramjet is unique as a missile power unit. It gives the missile designer and the user much greater flexibility than any other form of propulsion.

Bloodhound is guided by a sophisticated homing system in which a ground-based radar illuminates and tracks the target. Missiles can be fired singly or in salvoes. The ability to fire salvoes provides the Air Defence Controller with the operational flexibility he requires.

Bloodhound is aerodynamically unique. It has a monoplane moving wing which both lifts and steers the missile and gives quick response, especially at high altitudes.

Bloodhound has now been developed to give more range at all altitudes and to deal with both faster targets and electronic counter measures.

BLOODHOUND HAS BEEN ORDERED BY BRITAIN, SWEDEN AND AUSTRALIA

BRISTOL/FERRANTI

Bloodhound

GUIDED WEAPON SYSTEM

ENGLISH ELECTRIC AVIATION LTD. A Company of

BRITISH AIRCRAFT CORPORATION

ONE HUNDRED PALL MALL LONDON SW1

Jet psychology begins at the beginning

Jet Provost

BRISTOL SIDDELEY VIPER TURBOJET

for all-through jet training

Pilots who learn to fly right from the start in the Jet Provost have a better mental approach to the art of flying. They absorb jet psychology, become familiar with jet engine handling and control. They fly at jet speeds and jet heights and become accustomed to the essentials of modern military flying such as flaps, air brakes, retractable nosewheel undercarriage, V.H.F. and D.M.E. jet and instrument flying techniques. No time is wasted teaching techniques which must later be 'unlearnt'.

And as training progresses they attain higher standards and many exercises previously only possible on advanced jets can be done as well yet at much less expense in the Jet Provost.

An engine change time of only 2½ hours is just one of the features which give the Jet Provost an extremely high utilisation factor.

HUNTING AIRCRAFT LTD LUTON AIRPORT LUTON BEDS A Company of

BRITISH AIRCRAFT CORPORATION

ONE HUNDRED PALL MALL LONDON SW1

Production and Development of the Caravelle

By Louis Giusta, General Manager, Sud Aviation, Paris

On completion of his studies at the Ecole Polytechnique and the Ecole Nationale Supérieure de l'Aéronautique, Louis Giusta entered the French Ministry of Aviation as an engineer, from which position he rose to that of Technical Manager. In 1946 he became Operations Manager at Société Nationale de Constructions Aéronautiques du Sud-Est, a position in which he remained for eleven years, assuming responsibility for prototype construction and manufacture. When Sud-Est merged with Ouest-Aviation in 1957 to form Sud-Aviation, Louis Giusta was appointed Deputy General Manager. Later, as General Manager, he took charge of production, customer service and administration. He played a decisive part in the development of the Caravelle *and is thus the best qualified man to report on the technical problems of this major programme of the French aircraft industry.* *Editors*

In every field of endeavour, events occur at such a speed that, in the eyes of the world, the preoccupations of the moment overshadow the questions to which so much importance had been attached a few months previously.

Consequently, for all those who are concerned with air transport, it seems quite normal that today 58 *Caravelles* are in regular service with 9 airline companies throughout the world, and that 4 aircraft leave the production line monthly. Yet less than two years ago, at the beginning of 1959, observers throughout the world, who had applauded the success of the prototype *Caravelles* and had admired the demonstrations of the operational qualities of the aircraft in Europe and in America, openly expressed their misgivings. They doubted the ability of the French industry to complete an undertaking of such magnitude as the series production of a jet aircraft weighing 45 tons, and also to maintain the rigid delivery schedules required to meet the demands of the airlines. Furthermore, they were not convinced that the behaviour of the aircraft in commercial operations would provide the safety and regularity in performance that was essential for profitable operation on a world wide scale. Our industry, in fact, had no experience during its history of such production in the civil field, a field which, as the readers of *Interavia* are fully aware, has its own special peculiarities.

The challenge was accepted, and in May 1959 the first 6 *Caravelles* entered service on the appointed dates on the routes of Air France and SAS. Since then, our aircraft have been delivered punctually and even in advance of the contract date. The accompanying diagram shows the progress of orders and deliveries.

The enthusiastic reception that the passengers have given to our aircraft is well-known. For the operating companies, this popularity has been displayed in terms of high load factors. Allied to this commercial success there has been the excellent performance of the aircraft in operation. Consequently, against the main criteria of series production: delays, quality of manufacture, after-sales service, the French industry, which has produced many successful prototypes in its career, has now produced the proof that it is competitive with the established constructors of transport aircraft.

The means employed to achieve this success and the methods adopted to maintain a programme which was established in 1956, have already been described. I do not propose to repeat all the details but merely to recall some salient points.

Production of the aircraft involves the participation of 411 French and foreign companies. Of these, 148 are engaged in the construction of the airframe. This construction, including spare parts and modifications, occupies more than 38 percent of the French airframe industry.

In particular, I would like to deal with some of the main problems which have arisen during the last two years of the *Caravelle* programme, to show that the closely knit Sud Aviation team under the presidency of Georges Hereil has continuously improved the original aircraft, and that the initial success was not due merely to a stroke of good fortune.

The development of the *Caravelle* has been directed along three distinct lines:

- improvement of performance;
- modernization of the aircraft and equipment;
- improvement of the performance of the aircraft in service, by the correction of faults encountered in operations, in order to increase safety and reduce maintenance.

It can be seen today that the *Caravelle I* has been followed by the *Caravelle IA, III, VI, VIR,* and the *Caravelle VII* and *X* are shortly to appear. Out of the first six types, 23 different versions have been built to fulfil the customers' requirements. This situation demonstrates the flexibility which the production departments have displayed. In fact, up to the 55th aircraft, no more than two successive aircraft were delivered in the same version, and as new types appeared the production of the older versions was continued.

The improvement of performance

The speed has been increased by more than 60 mph (455 mph to 525 mph) between the *Caravelle I* delivered in March 1959 and the *Caravelle VI* which will be delivered to Sabena in January 1961. This increase is due chiefly to the fitting of more powerful engines (from the original Rolls-Royce *Avon* 522 of 10,500 lb thrust, the *Avon* 533 of 12,600 lb thrust, the General Electric CJ-805-23C of 17,000 lb thrust and soon the Pratt and Whitney JT8D-1 of 14,000 lb thrust) and to several aerodynamic modifications. The range has more than doubled for the same payload (8 tons), from 950 miles for the *Caravelle I* to 2,000 for the *Caravelle VII*, and rising through 1,330, 1,375 and 1,650 for the intermediate types. This result has been achieved by structural reinforcements which have enabled the take-off weight to be increased from 95,500 to 116,600 lb, and by the improved specific consumption of recent engines, in particular those of the by-pass type.

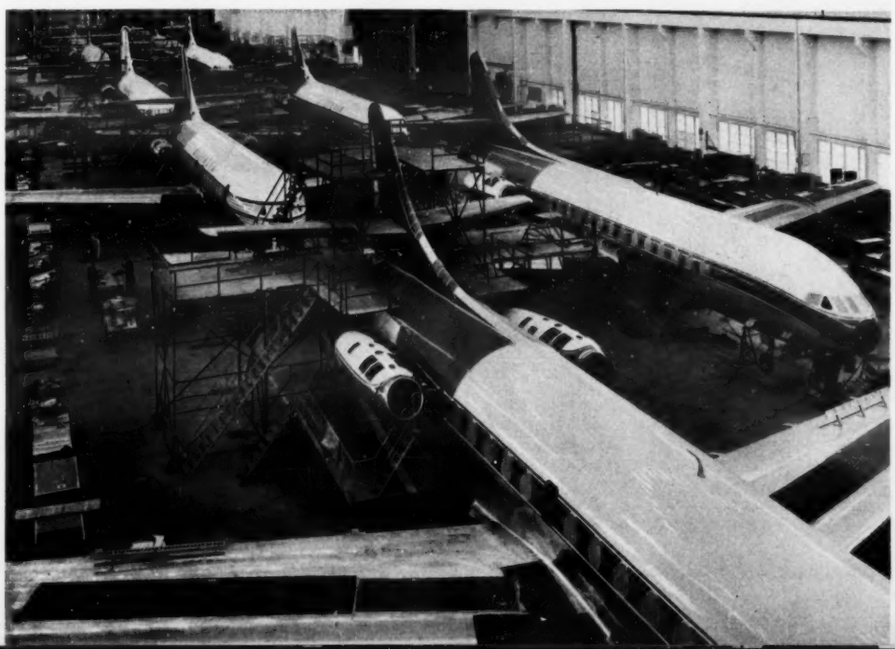
The take-off distance has remained practically unchanged, while the landing distance has been reduced by improvements to the brakes and the addition of spoilers and double slotted flaps. This has been achieved in spite of the increase in the all-up weight of the aircraft. The VNo (normal operating speed) has increased from 300 knots to 315 and then to 320, and we hope to attain 340 knots.

Modernization of the aircraft and its equipment

The following details are representative of this work:

- the fitting of engine silencers on the *Avons* installed in the *Caravelle III, VI* and *VIR* to reduce the noise occasioned by the increased engine thrust;
- the fitting of by-pass engines which do not

Final assembly of the Caravelle in the new Georges Héreil hall at Sud Aviation's Toulouse-Blagnac plant.



require silencers but necessitate a complete redesign of the engine nacelle;
– the installation of a passenger oxygen supply;
– the replacement of the braking parachute by thrust reversers at the request of American customers;
– a complete redesign of the structure and layout of the cockpit to improve the visibility, and the installation of the most modern flight and navigation instruments with integral lighting. The improvements in cockpit visibility have made it necessary to carry out further fatigue and windscreen fracture tests, and the structural changes, in particular the fitting of non-magnetic steel windscreen supports, have presented the manufacturing departments with many difficult problems while the aircraft was in full production.
– the installation of a constant frequency (400 c/s) alternating current power supply on the *Caravelle VII* and *X*. Other modifications have been carried out in the interests of standardization with American procedures. As an example, the hydraulic fluid FHS 1 has been replaced by Skydrol in the *Caravelle VI R* onward. The corrosive properties of Skydrol have compelled us to re-examine all the methods used for painting, filling, insulation of electric cables, sealing of pipeline joints and unions and also the hydraulic system itself. The difficulties arising from such a change, both on the production line and in the technical specifications for spare parts, can be appreciated. A section of the nacelle and of the fuselage-nacelle pylon on the *Caravelle VIR* with thrust reverser, is of 17.7.PH stainless steel, and this unusual application has presented some special problems to the workshops.

Another modification has been the installation of an auxiliary gas turbine for cabin air-conditioning when the aircraft is on the ground and the engines are stopped.

Finally, a series of tests are commencing on the operation of an automatic blind landing system.

Improvement of the performance of the aircraft in service

Up to November 30th, 1960, the *Caravelles* already in service had completed 80,000 flying hours on short-haul routes. With an average flight time of 1 hour 30 minutes between take-off and landing, this type of service is particularly demanding on both structure and equipment.

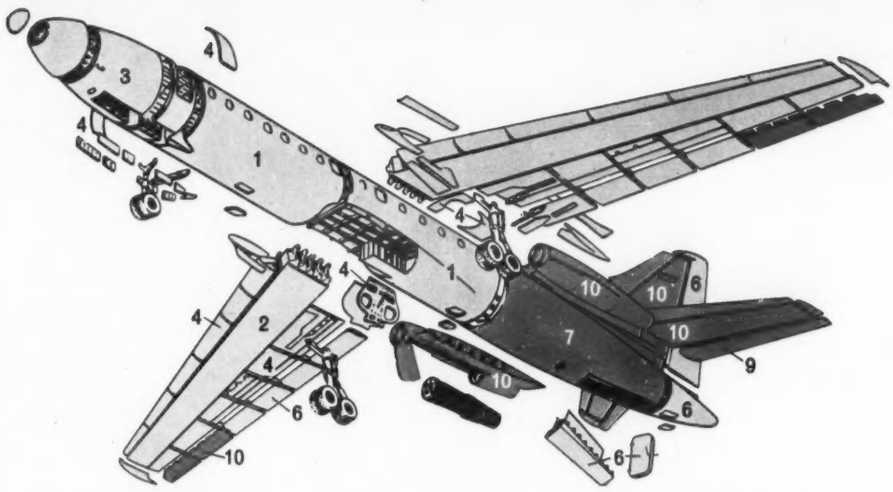
To achieve such results, it has been necessary to effect modifications to the aircraft in production and in service, based on experience gained in operation. Although the *Caravelle* has not suffered from the "teething troubles" which affect so many commercial aircraft, certain defects have had to be remedied. For the most part these have been the short service life of certain parts. More than 350 modifications of this type, out of a total of 800, have been carried out, either during production or on the customers' premises. The most important of these have been in connection with the hydraulic servo circuits and pipelines. The brake units have been converted by Hispano Suiza by the replacement of the standard linings and copper discs with steel discs and special cerametal linings, which greatly increase the braking efficiency. The antiskid system has also been modified at the same time by the substitution of double action *Maxaret* in place of the single action unit previously fitted.

On the rudder and elevators, small cracks have developed which have reduced the service life of these controls. A test bench has been specially constructed to reproduce flight conditions, and the control surfaces have been extensively modified. The control cables and pulleys have also been modified to ensure an acceptable length of service life.

Among the trials which have been carried out during the past two years, special mention should be made of the pressure tank fatigue testing of the complete airframe.

These tests were started in December 1958, and have followed a programme which is perhaps one of the most extensive and searching that has ever been undertaken prior to the entry of a commercial aircraft into service. By July 1960, 100,000 simulated flights had been carried out. This figure should be compared with the 15,000 to 20,000 flights which a *Caravelle* is expected to make in 10 years of service. After the 100,000 simulated flights were completed, the loadings were increased to a figure well above the maximum of the programme, in order to achieve structural failure. These excess loadings were applied 3,600 times before failure occurred. This demonstration of the structural strength is ample confirmation of the robust qualities of the *Caravelle*. The tests enabled details of the periodic inspection schedule to be defined and also to indicate the points requiring further reinforcement, so as to reduce future maintenance costs.

The foregoing remarks illustrate that to maintain a fleet of civil aircraft in service, it is necessary to supply the customers with continuously up-to-date information on newly developed equipment and techniques. All the following closely interlinked departments are called upon to provide this service:



The distribution of airframe manufacture. The portions which are shaded in light grey are built in Sud Aviation's various plants, the portions shaded in dark grey are supplied by subcontractors (see table below). The figures in the drawing refer to the first column of the table.

Plant	Component	Percentage share of complete aircraft
I – Sud Aviation factories		
1 Toulouse	Fuselage centre section Final assembly Equipment components Testing	28.4
2 Bouguenais	Wing spar boxes Wing assembly	14.6
3 Marignane	Fuselage nose	12.1
4 St-Nazaire	Wing leading edge and other parts of wing Parts of fuselage	8.6
5 Courbevoie	Cabin trim Parts of engine mounting	5.4
6 Rochefort	Camber flaps Rudder Parts of fuselage	3.5
	Total	72.6
II – Subcontractors (France)		
7 Latécoère (Toulouse)	Fuselage rear	5.4
8 Breguet (Anglet)	Equipment components	3.5
9 Forges La Boissière (St-Florent/ Cher)	Elevator	0.6
	Total	9.5
III – Subcontractors (other countries)		
10 Fiat (Italy)	Engines mountings Vertical and horizontal tailplanes Ailerons	8.1
IV – Component suppliers, 148 firms		9.8
	Total	100%

This view of the underside of the fuselage shows how the two wings mate.

– the sales department, which is always available to advise the customer on the suitability of a particular modification;
– the design offices, which are compelled to find a solution to a problem within the rigid terms which lead to aircraft profitability, and in the least possible time. Our design offices have demonstrated that French engineers, who have the unfortunate reputation of leaving the exploitation of their inventions to others, know how to apply themselves to operational requirements and to fulfil thankless tasks to the last detail;
– the production and inspection departments, which must follow the fluctuations of modifications, and produce the required parts without any relaxation in quality or delivery dates;
– the flight test department, which must carry out the certification tests for each type and make special tests on certain versions;
– the after-sales service, which represents the advanced line, most exposed to the criticism of the customers.

The after-sales service

The decision to form an after-sales service in 1957 demanded particularly strenuous efforts, since a vast amount of work has been necessary to enable us to attain the standards of the old-established civil aircraft constructors. The following figures give some idea of the extent of these efforts.

Training of operating companies' personnel

Since the commencement of training courses in 1958:
– 154 French trainees have attended the course;
– 170 foreign trainees have also completed the course which was given in English;
– 700 sets of instruction manuals, representing a total of 1,600,000 pages, have been distributed in French and English.

These figures refer to classroom instruction given at Toulouse. At the same time, training courses have been given at the operating companies' bases by members of our staff, who have been detached to work in liaison with the instructional personnel of the companies.

Documentation

To date, Sud Aviation has distributed 18,000 manuals to the customers, representing a total of 8,900,000 pages. This documentation has been prepared in accordance with the American specification ATA 100, a specification which is being universally adopted by all airline companies today. During 1961, the after-sales service will produce microfilmed sets of the aircraft drawings which will be made available to the customers.

Spare parts service

In 1960, the after-sales service introduced a punched card system covering the technical specifications of 25,000 parts and exchange units, and is at present distributing the punched cards and corresponding listings. During 1961, the mechanization of orders so as to conform to the American specification ATA 200 will be undertaken. Sud Aviation has already achieved an excellent reputation for speed and efficiency in the supply of parts for emergency repairs. These are dispatched either from the factory or from stocks of insurance items which have been established at Le Bourget and New York. A further store is at present being established on the West Coast of the USA for American customers. The number of rush orders completed to date is approximately 4,000, and represents a weight of about 46 tons.

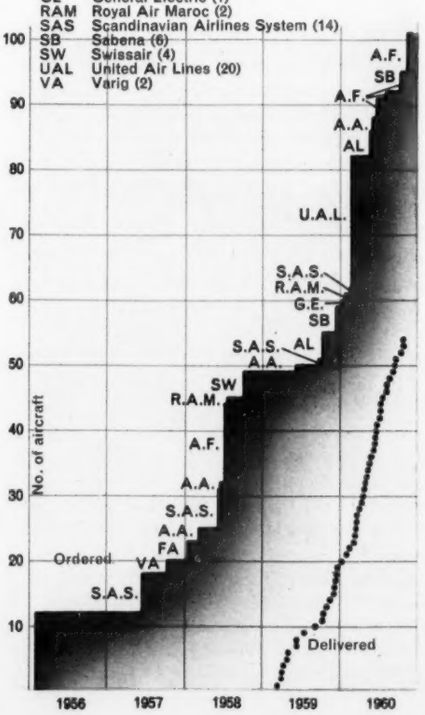
The Marignane plant builds the *Caravelle* fuselage nose.

Jigs for riveting the fuselage skin to the frame ribs (Toulouse).

Orders and deliveries of the *Caravelle*
(as at November 3rd, 1960)

Key to abbreviations (total number of aircraft ordered in parentheses)

AA Air Algérie (6)
AF Air France (35)
AL Alitalia (8)
FA Finnair (3)
GE General Electric (1)
RAM Royal Air Maroc (2)
SAS Scandinavian Airlines System (14)
SB Sabena (6)
SW Swissair (4)
UAL United Air Lines (20)
VA Varig (2)



Detachment of engineers and specialists

Up to the present, a work force equivalent to 11,000 man/days has been supplied by the Field Services to the operating companies. The assistance of these technicians, who take part in operations if required, has been greatly appreciated by the customers.

In order to assist the departments mentioned, and to examine all the problems which arise in the operation of the *Caravelle*, Sud Aviation has organized a series of annual meetings with all present and future operators, together with the engine manufacturers and suppliers of the main items of equipment. The first symposium was held at Toulouse from September 28th to the 30th, 1960, in an extremely cooperative and constructive atmosphere and was warmly welcomed by all the participants.

Conclusion

What we have done has already been done previously by foreign aircraft constructors. The object of these lines is to re-emphasize the difficult problems which arise in the sale of commercial transport aircraft. This organization of design, production and after-sales services developed by Sud Aviation for the *Caravelle*, forms a unit which has already proved its capabilities. Such an organization is of considerable importance, as few of its kind exist in the Western world, and it is the only one of its size in Western continental Europe. It is obviously in the interests of the European community to use it to the maximum of its capability. ◆◆

Some Thoughts on Future Civil Transports and their Safety Problems

By D. M. Jameson, M. B. E., A. F. R. Ae. S., Air Registration Board, London

The year 1960 has seen, in addition to the continued unobtrusive service of many long-established types, the continued process of mutual accommodation between operators and their large subsonic jet transports. While considerable pains have been taken to make these aircraft as safe and economical as possible, I think all will admit that we are awaiting, with interest and continued vigilance, the crop which should spring from the seeds that have been sown. These aircraft have brought into the aeronautical public eye a number of safety problems (e. g., those connected with take-off and with roll-yaw stability), the solution of which may well affect the future. In particular, the precision with which they must be operated is greater than for the great bulk of previous types and, if the appropriate operating data are recorded, they may well prove to be a vital element in the extrapolation of our experience to provide economic safety requirements for future designs.

In the relatively near future, we will have the continuation of three themes, namely, the propeller-driven box-car (primarily for minimum-cost regional cargo traffic), the multi-engined helicopter, and the tail-jet.

The flying box-car really poses no new problems in safety requirements, though history shows that the meeting of handling and performance requirements with utilitarian fuselage shapes has not always been easy. Since such aircraft are designed to cut operating costs to the bone, there will, perhaps, be requests for re-examination of the engine-cut performance requirements, but in view of the fluctuations in reliability which occur with any aeroplane, the writer sees little scope for economy in this direction. A more promising activity would be to investigate the present system of engine ratings, as applied to propeller turbines, so as to ensure that maximum use is being made of the power which really is available after failure of one power unit, without increasing the risk of a second power unit failing to more than that implied by present requirements (about 1/2000 per hour of operation after the first failure). Such new ratings would clearly have to cater for the longest time which the aircraft might have to fly with one power unit inoperative.

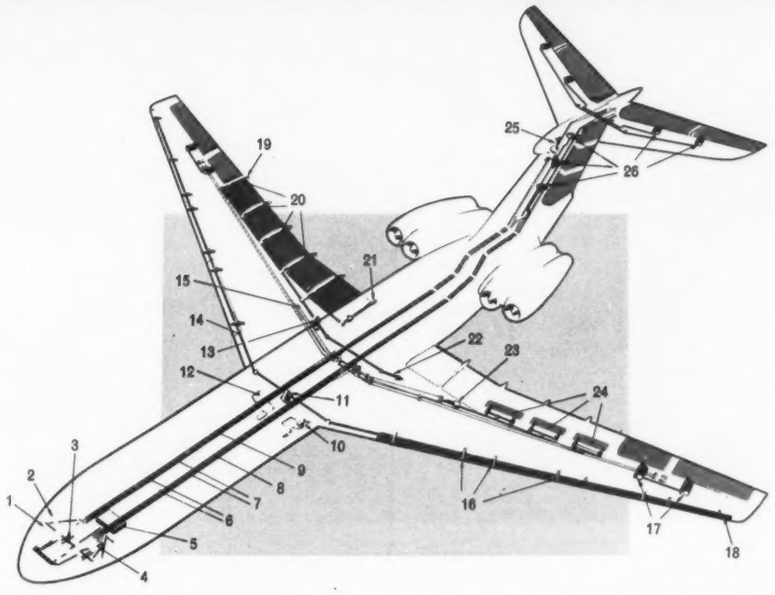
"Contingency" ratings which embody this line of thought have already been developed in the U.K. for turbine-engines intended for use in multi-engined helicopters, where the case for their use is clear-cut. It is to be hoped that other countries will soon adopt similar requirements, and thus enable wide-scale experience of such a scheme n this special application to be obtained as soon as possible. The subsequent extension of this thinking to fixed wing aircraft, in particular twin-turboprop feeder-line aircraft, presents a number of difficult problems, and it would be unwise to modify their requirements until the helicopter experience has been assimilated. However, the long-standing difficulties of establishing profitable feeder-line operations would be greatly eased by the ability to produce an even more economical feeder-line aircraft to modern transport performance requirements. Even though the potentialities of the turbine engine for contingency ratings in this sphere cannot yet be assessed accurately, it would be worth while making some economic studies of the scope which exists for reducing operating costs by this means (taking account, of course, of any repercussions on engine development and maintenance costs).

To make full use of multi-engined helicopters, it will be necessary to develop reliable all-weather take-off and landing ability, and to establish clearance for flight in turbulent cloud and its attendant problems of structural integrity and control.

In the jet transport field, the advent of a whole range of tail-jet aircraft shows much promise. The Comet led the way in providing easy handling characteristics under asymmetric power; this characteristic not only removes one hostage to human fallibility, but facilitates the operation of advanced automatic piloting equipment. The tail-jet has further virtues in that the engines should remain clear of spilt fuel in minor accidents, and both occupants and structure benefit from reduced noise levels. There are, of course, a few special problems to be met: for example, detachment of the engines in crash conditions must be provided against at least up to the level (12 g forward) prescribed for heavy items of equipment in the cabin, and important services taken up the leading edge of the fin need special protection against impact damage; but there is no reason to believe that this configuration presents special difficulty.

The next generation of large transports is likely to be most noted for the guidance and navigational equipment fitted. Consider firstly the auto-pilot; in the past it has been regarded (from the airworthiness point of view) as a luxury, which could malfunction or disconnect itself as often as it liked, provided it did not break the aeroplane or dive it into the ground. In the forthcoming aircraft it will be wanted for a more responsible role—for example, automatic flare-out in landing and later blind landings and, one hopes, for maintaining control in really rough air. These tasks mean that the auto-pilot must have a high degree of authority, instead of cutting out when the going becomes difficult; this means that run-away failures, which could break the aeroplane, must be effectively eliminated, a requirement which virtually precludes a simple single channel system. On the other hand, uninhibited recourse to multiple channels, with the currently-experienced component reliabilities, would delay take-off far too frequently. Therefore, not only must component reliability be greatly improved, but also suitable use must be made of the multi-channel principle or some other equally effective measure. Any complementary ground services must, of course, have similar reliability, which calls for the closest co-operation between those responsible for the safety standards in these hitherto virtually independent fields. Establishment of compliance with the overall reliability criteria (which must give a fatal accident probability of the order of one in ten million per landing, or less, if the system is not to cause more accidents than it avoids) will require very rigorous fault analysis, embracing, so far as the aeroplane is concerned, not only the auto-pilots but their power supply, elements of the aircraft control system, and the various items which supply information. For this and other reasons, it may be difficult, without very major modifications, to add a satisfactory blind landing system compatible with normal civil safety levels to an aeroplane in which proper provision has not been made for it in the initial design.

Some interest has been shown in the possibilities of improving the next generation of jet transports by the application of boundary layer control. The use of flap blowing, with the background of military experience which exists, is likely to come about first, though it should be pointed out that whether or not its use will be profitable will depend very much on the safety requirements applied to the aeroplane. As with other new features, the aim must be to preserve at least the existing level of safety, but since current requirements prescribe take-off and approach speeds which are related to a power-off stalling speed, and a $C_L$max which does not vary over these ranges of speed, we must go back to fundamentals and examine the qualities actually needed; in particular, we must consider the margins of gust resistance, and normal acceleration, which operational records show to be necessary over speed ranges covering the intended take-off, approach and landing speeds. Research in this field, and that of take-off transition, may throw light on the safety requirements for a whole range of aircraft, including the so-called STOL varieties.



The control system of a jet airliner with rear-mounted engines, the Vickers VC.10. The variety and distribution of control surfaces possible on large aircraft guarantee good flying qualities over a wide speed range, though additional power, control and compensation devices must be provided, resulting in appreciably larger dimensions and increased costs.

1 – rudder pedals
2 – control column
3 – manual disconnecting unit for lateral control system
4 – tension regulators
5 – artificial feel unit
6 – rudder signal run
7 – elevator signal run
8 – aileron signal run
9 – spoiler signal run
10 – ram air turbopump in extended position
11 – slat gear-box
12 – ram air turbopump in retracted position
13 – flap gear-box
14 – torque shaft
15 – to starboard spoilers
16 – slat units
17 – power control units
18 – synchro unit
19 – synchro unit
20 – flap units
21 – synchro unit
22 – to port flap units
23 – airbrake signal input
24 – spoilers
25 – tailplane incidence control unit
26 – power control units

A further problem will be to decide on the minimum ability to reduce speed or increase gradient of descent during the approach, since the use of high idling r. p. m. to provide boundary layer control may require special countermeasures. There will, of course, also be engineering problems, but these appear to be less difficult than those of stating sound handling requirements.

Lastly, in thinking of future technical problems, is the group posed by possible supersonic transports. For these types, there are the additional difficulties of obtaining knowledge of the environment, and of practical demonstration of compliance with the eventual requirements. In the course of the latter, much flying will be needed, if we are to have the customary confidence that the normal level of safety will be achieved. The actual amount of this flying will depend on many factors, and not least on the willingness of operators to commence transport operations with conservative margins on the understanding that these will be reduced if the data so warrant. For such a procedure to be practicable, the cooperation of flight crews will also be required, since it will mean, in some cases, the abandonment of the "what we have we hold" philosophy sometimes held, in which any reduction whatever of margins is opposed.

This brings us to consideration of the major administrative problem in the certification of most aircraft embodying major technical advances, that of predicting the conditions of certification early enough for them to be taken account of before the key design features are frozen. In this competitive world, designers naturally wish to embody the latest techniques in their aircraft; thus, the close cooperation of operators and research establishments is needed to ensure that the basic information needed for requirements is obtained early enough, i. e., when the new design information becomes available, if not before. Much of this airworthiness research is of a basic and continuing nature, not chargeable to specific projects; it is important that the full financial implications of this be faced up to.

An important factor which can help or hinder progress in this field is that of international discussions; in this respect, a few things are clear, namely,

(a) frequent informal contact between experts in different countries, to discuss basic principles and assumptions, is necessary if major differences in outlook are to be avoided and the best use is to be made of all available experience;

(b) these contacts must be distinct from, and considerably precede, the meetings to discuss any corresponding requirements or validation agreements, which represent a much later stage of development;

(c) such later agreements must leave scope for flexibility in matching detail requirements to the special features of individual types if they are to help, and not hinder, safety;

(d) once a technical agreement on key requirements has been reached, it should be embodied in the national requirements with minimum delay. The pace of progress in the jet age will not permit the same ground to be argued over more than once.

In general, it may be said that the developments in future transports, however advantageous, present us with some important safety problems; while these are by no means insoluble technically, their solution at dates which are early enough to be fully effective will require considerably more effort than the aviation world has hitherto been prepared to give. ⟿

Final assembly of the D.H. *Comet 4*, in the BOAC long-range version, at de Havilland's Hatfield works.

The Helicopter as a Weapons System

F. L. von Doblhoff, Director of Engineering, Europe, Boeing Airplane Company

Fig. 1: The Boeing-Vertol 107 during compatibility exercises with an Army tactical missile system.

Along with the rapid advance in defense technology during the past decade, we have witnessed the appearance of what is commonly known as the weapons system concept. A weapons system consists of the weapon itself—the term weapon being used broadly to denote primary items of military equipment regardless of whether they are offensive, defensive or logistic—and of all the equipment needed to deploy this weapon most effectively. A missile, for example, could be the weapon, but the weapon system would include all the equipment needed to transport, erect, fuel, launch and control this missile. A knight with armor, sword, horse, saddle and shield is also a weapons system in the sense of this definition. The weapons system as such, therefore, is nothing new—what is new is the awareness of the system concept, the awareness of the fact that integration of the weapon with all its associated equipment at the very beginning of a new development will lead to greater efficiency. It is probably the missile, so obviously useless when it is not accompanied by all the ground equipment needed for its operation, which has caused this awareness, but it was not very long before the same type of broader thinking was accepted in the development of airplanes. It was recognized that an airplane designed to be integrated with the various types of armament and electronic equipment it might be called upon to carry and with the ground facilities by which it might be serviced, would have definite operational advantages over an airplane which was not based upon such system awareness from its inception.

Depending upon the nature of the weapon itself, the types and functions of the components with which it must be integrated to become an efficient system are quite different. The missile, for instance, is usually a one-mission type of weapon and therefore has little need to be matched to numerous different payloads, but it is so demanding as regards ground equipment that less than half of the total cost of the system is usually spent on the weapon itself, and more than half on the remaining portions of the system. Airplanes, by contrast, are less demanding in the way of ground equipment because they carry their own landing gear, check-out instruments and crew. On the other hand, they are more demanding as regards integration with numerous different payloads and kits for special missions.

Fig. 2: Mockup of an ASW mission module being fitted into the fuselage of a Boeing-Vertol 107. The module will contain complete sonar equipment for ASW operations, with two crew positions; windows, the opening for the sonar equipment, and electrical connectors exactly match corresponding points in the helicopter fuselage.

At about the same time as the advent of turbine-powered helicopters, the mission system concept also began to enter into the design philosophy of this sort of aircraft. The helicopter is least demanding as regards ground equipment, as indeed it must be in order to exploit its advantage of independence from airports and hence from other bases at which ground equipment could be made available. But on the other hand its versatility makes it highly desirable to extend the number of missions for which it can be used, and the number of different payloads and mission kits which it can carry if it is properly designed from the beginning. While ground equipment is the major portion of a missile weapons system, getting away from ground equipment is the major objective in the helicopter system. While missile system integration aims at helping the missile to perform its unique mission, helicopter system integration is designed to make the helicopter as adaptable as possible for very numerous tasks. This is the first characteristic of the helicopter weapons system.

A second fundamental aspect of the helicopter weapons system arises from the basic concept of the universal vehicle which can operate from entirely unprepared areas. The helicopter will often need the components of its weapons system in areas where only helicopters can land and where no other air or surface transportation is possible. As an example, change-over from a personnel-carrying kit to an anti-tank weapons kit may have to be made on a mountain top, or a helicopter may have landed safely after engine failure but in an inaccessible area, where portions of the weapons system designed for replacement of engines would be needed to repair the damage at the site of the landing. It follows, therefore, that all portions of a helicopter weapons system must themselves be transportable by helicopter. If we take this observation one step further and consider the obvious desire to avoid using one type of helicopter to carry the weapons system components for another, we are led to the even more demanding conclusion that all items of a helicopter weapons system should be transportable by the very helicopter they are intended to serve. It is obvious how fundamentally different the weapons system concept becomes when it is applied to helicopters rather than to missiles or airplanes.

The third important aspect of the helicopter weapons system results from the fact that the helicopter, in most cases, is a support aircraft. It is rarely the prime weapon itself. One of the

most important missions of the helicopter of the future is probably the assistance it can furnish towards the major defense objective of making missile systems less vulnerable by making them more mobile. Especially in the densely populated areas of Europe, where ground transportation has been known to break down quite frequently in periods of emergency because of large concentrations of troops and civilians on the surface transportation channels, the helicopter may well be the only way to provide this mandatory mobility. The important consideration here is that the helicopter will then itself become part of a larger weapons system, and appropriate integration must be considered in the earliest stages of establishing requirements and laying out design.

Fig. 3: The *Pershing* missile launcher is loaded into the mockup of the *Chinook*. U.S. Army specifications require the helicopter to be capable of carrying all the components of the *Pershing* system.

Fig. 4: An engine being replaced on a *Chinook* mockup. A basic requirement of a helicopter weapons system is that it must be able to transport large items of equipment for servicing and maintenance purposes to other helicopters of the same type in inaccessible forward areas. The photograph shows how the engine change can be carried out by no more than four men.

Turning now, with the above thoughts in mind, to some of the specific items of equipment which should be developed concurrently with the helicopter itself, and to the methods needed to integrate the helicopter into other weapons system, it is convenient to divide its tasks into two major categories of operation: flying, which consists primarily of accomplishing missions, and ground operation, which is needed for service and maintenance.

Mission accomplishment

As helicopters are finally becoming faster, cheaper to operate, more reliable and fully capable of flying under IFR conditions, and as the awareness of their great utility in future highly mobile military operations increases, they will be used for more and more tasks. At the same time, the helicopter remains a logistic and support aircraft where the attainment of maximum performance is not of the same paramount importance as it is in primary weapons systems.

It will not, therefore, be economically feasible to develop many specialized helicopters, each best suited for one task. It is also not possible to install simultaneously all the equipment needed to accomplish the many missions required. This would mean that ASW gear, mine-sweeping gear, anti-tank weapons, troop seats, litters and many many other items would be carried at once and, quite obviously, the helicopter would no longer be able to perform any one mission well; at the same time, it would have become exceedingly expensive.

It follows, then, that a single helicopter should be able to accept numerous different types of equipment, and the system concept suggests that all the equipment needed for one particular mission should be packaged in quickly interchangeable units, the helicopter itself having permanent installations to accept these units without delay. This requires space, structural and electrical provisions, cockpit installations and many others. In the design of the most recent Boeing-Vertol helicopter systems the term "mission module" was coined for these packaged groups of equipment which allow rapid changeover by unskilled personnel.

Some of the major mission modules presently offered with the Boeing-Vertol 107 helicopter are designed for troop and litter carrying, crane operations, towing, armed attack, fire fighting, rescue, long range operations, mine-sweeping, mine laying, anti-submarine warfare and several other lesser missions.

The anti-submarine warfare module can well serve as a typical example of the mission module concept. A mockup of this unit is shown in *figure 2* in the process of being inserted into the fuselage. This package consists of a cabin containing all of the electronic and acoustic gear needed for operation of a modern sonar system, and the stations for a crew of two. Integration of this unit with the helicopter requires that the bottom opening for the sonar ball must match and seal against a mating opening in the bottom of the helicopter fuselage, that windows in the module must match windows in the fuselage, that electrical connectors mate etc. Obviously this arrangement causes a weight penalty when compared to a specialized ASW helicopter, where the same pieces of equipment are more or less permanently attached to the fuselage structure itself. But this weight penalty is not large and, as a by-product of the module concept, also offers two important advantages. One is the outstanding noise insulation characteristics which are exceedingly important in sonar operations. Probably this hut-in-house arrangement is the lightest way to achieve a given amount of noise attenuation, so that the penalty mentioned before may not be one after all. The second advantage is the quick interchangeability of the entire sonar

Fig. 5: Built-in maintenance facilities on the Boeing-Vertol 107. Access panels for servicing and maintenance open out to become work platforms, thus reducing the need for ground-based equipment.

system, which enables the helicopter to remain operational when malfunctions in the complex ASW equipment occur. Instead of the helicopter remaining grounded until the fault is corrected, flying can continue with one module while overhaul progresses on the other.

Not all modules, of course, can be packaged quite as neatly as the one mentioned above. Modules for mine-sweeping and many other missions consists of several separate packages which must be attached in different places on the helicopter, but the basic concept is common to all: mission modules are developed concurrently with the helicopter so that the entire system is one integrated functional unit.

It is interesting to note that the weight penalty in the basic helicopter caused by the provisions to accept all of the modules mentioned has amounted to no more than 130 lb, certainly an acceptable amount if we consider the degree of additional utility provided by the weapons system concept.

As concerns integration with other systems already in existence, the auxiliary tanks for range extension are the ones used in the F-104. *Figure 1* shows compatibility exercises between the 107 and an Army missile system, and *figure 3* illustrates loading exercises involving the *Pershing* launcher and the mockup of the Boeing-Vertol *Chinook*, a helicopter required by specification to be capable of transporting all components of the *Pershing* missile system.

Figure 6 shows another proposed method of integrating the helicopter with several existing types of weapons at once, to amplify the Boeing-Vertol 107 system to include the anti-tank mission. Study of tactical situations likely to occur, particularly in Europe, has led to increasing emphasis upon this mission and to the recognition that reloading of launchers in flight should be possible to avoid the time loss otherwise needed for the helicopter to return to its base for reloading. *Figure 6* shows the use of the bottom hatch (the same one used in ASW missions for dropping the sonar ball, in rescue missions to hoist personnel and in crane missions to attach external cargo) for lowering reloadable wire-guided anti-tank missiles into launching position. At the same time, a rocket launcher can swing from inside the cabin, where it is reloaded, to assume a forward-pointing launching position and then return inside again for reloading. The rear ramp (the same one used for loading troops and cargo, for inserting other mission modules and for carrying long objects) is used for this purpose. *Figure 6* also shows smaller caliber rocket launchers and machine guns installed in the stubs and nose of the helicopter.

Another important problem requiring integration of the helicopter with its environment is the question of navigation under IFR conditions—a requirement closely related to mission accomplishment of the future. High moisture content in the air reduces visibility not only for the pilot but also for the infrared target-seeking devices likely to be used against helicopters. Movement under IFR conditions therefore becomes desirable, not only to avoid grounding of helicopters during inclement weather, but because these conditions of poor visibility might be the very ones during which the helicopter commander of the future might actually prefer to operate. Boeing-Vertol believes that, as a result, helicopter-borne radar equipment will become significant for IFR navigation in areas devoid of electronic assistance from the ground. Layout of the nose of the aircraft itself must even now make provision for the necessary space and configuration of non-metallic areas. The attainment of stability in the helicopter itself is obviously a prerequisite for achieving IFR capabilities. Boeing-Vertol concentrates—except for certain important Navy missions—on achieving stability without an autopilot, so that the pilot can retain full normal control over his aircraft.

In addition, there are many other features the designer can provide in the aircraft itself to increase the capability of the helicopter to perform as many missions as possible with minimum risk. Provisions for local armor are frequently required by new specifications. Floatation on water without the use of kits is provided in all new Boeing-Vertol helicopters. Wide range of center of gravity is of importance, especially when anticipating the need for integration with future missile systems, whose unknown length and c. g. locations may tax the helicopter to its limits.

Servicing and maintenance

In keeping with the special characteristics of the helicopter weapons system explained initially, the purpose of all measures to facilitate servicing and maintenance is—along with the obvious objective of minimizing the need for it—the abolition of ground facilities and not, as in many other weapons systems, their creation. This obviously requires permanent installation of some system components on the helicopter itself and design of helicopter-transportable components for maintenance operations that do not occur often enough to warrant a permanent installation.

Typical examples of permanent installations are steps and work platforms to avoid the use of ladders and stands. Since work platforms are generally needed when access panels are open, it is obvious that the panels themselves, when opened, become platforms. *Figure 5* illustrates the extent to which this philosophy has been carried in the Boeing-Vertol 107. The nose of the entire vertical tail opens up like a clamshell to reveal control and hydraulic systems inside, while itself becoming a work stand and a stairway to the rear rotor hub. The forward pylon folds out and turns into platforms. The rear ramp, when partially lowered, becomes a large and convenient work platform for engine overhaul. The fuselage top is strengthened to become a walkway from which the full length of all rotor blades is within easy reach. One might argue that this type of permanent installation on the helicopter does not reflect a systems concept, just good design—but it must be kept in mind that from the standpoint of ease of construction and of low weight it would be preferable to avoid the additional pieces installed. It is only when considering the entire system, the lack of stands and ladders in forward combat zones, and the desirability of conducting preflight operations on numbers of dispersed or camouflaged helicopters, that the designer is led to recognizing that the overall system is served better by adding to the permanent equipment of the helicopter features like the ones shown in *figure 5*.

Helicopter transport of the fuel supply needed by other helicopters—even to the extent of developing dump-truck techniques, the installation of a system which enables a helicopter to refuel by suction directly from barrels (the 107 is offered with this device), the provision of auxiliary power units for repeated engine starts without use of starter carts, and for prolonged radio operation from the ground—all of these things, by now well known in the industry, follow from the system awareness of recent years.

For maintenance operations needed less frequently—for example replacing engines, transmissions, rotor hubs etc.—larger helicopters will need special items of equipment if these operations are to be carried out in forward and inaccessible areas. Again it follows that these items of equipment must themselves be transportable by the same helicopter which they are to serve. An example of this is the requirement that the Boeing-Vertol *Chinook* must be designed for replacement of all large components by equipment carried inside the helicopter. *Figure 4* illustrates how, even in the mockup stage, it was necessary to prove that this requirement could be met by no more than four men.

In summary, the few examples cited above are intended to illustrate what specific measures have so far been taken to satisfy the three main requirements of the helicopter as a weapons system: first, adaptation to a maximum number of missions; second, making all items of the system transportable by the helicopter they are to serve; and third, integration of the helicopter system as a whole into other existing systems.

It is already apparent that the advantages attainable by the system concept are very substantial and that major helicopter projects of the future will follow the trends already established. ←

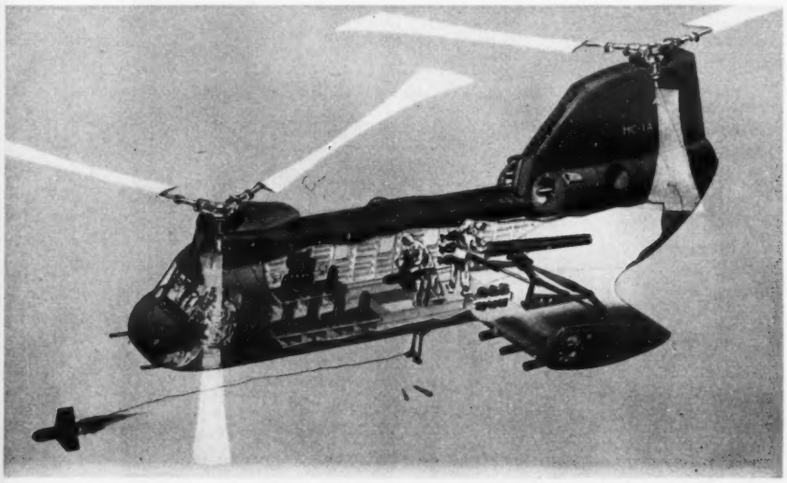
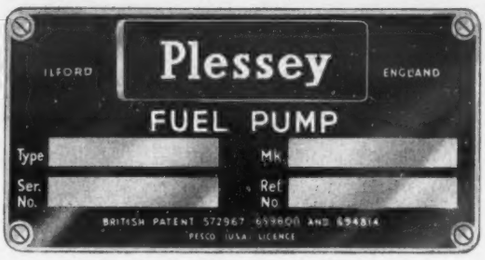


Fig. 6: The 107 equipped for anti-tank operations. The bottom hatch is used for lowering wire-guided anti-tank missiles for launching. At the rear, a rocket launcher can be swung down from inside the cabin to a forward-pointing launching position. Both launchers are reloadable in flight. Small rocket launchers and machine guns are fitted in the stubs and nose of the helicopter.

All the most advanced aircraft fuel pumps have this in common



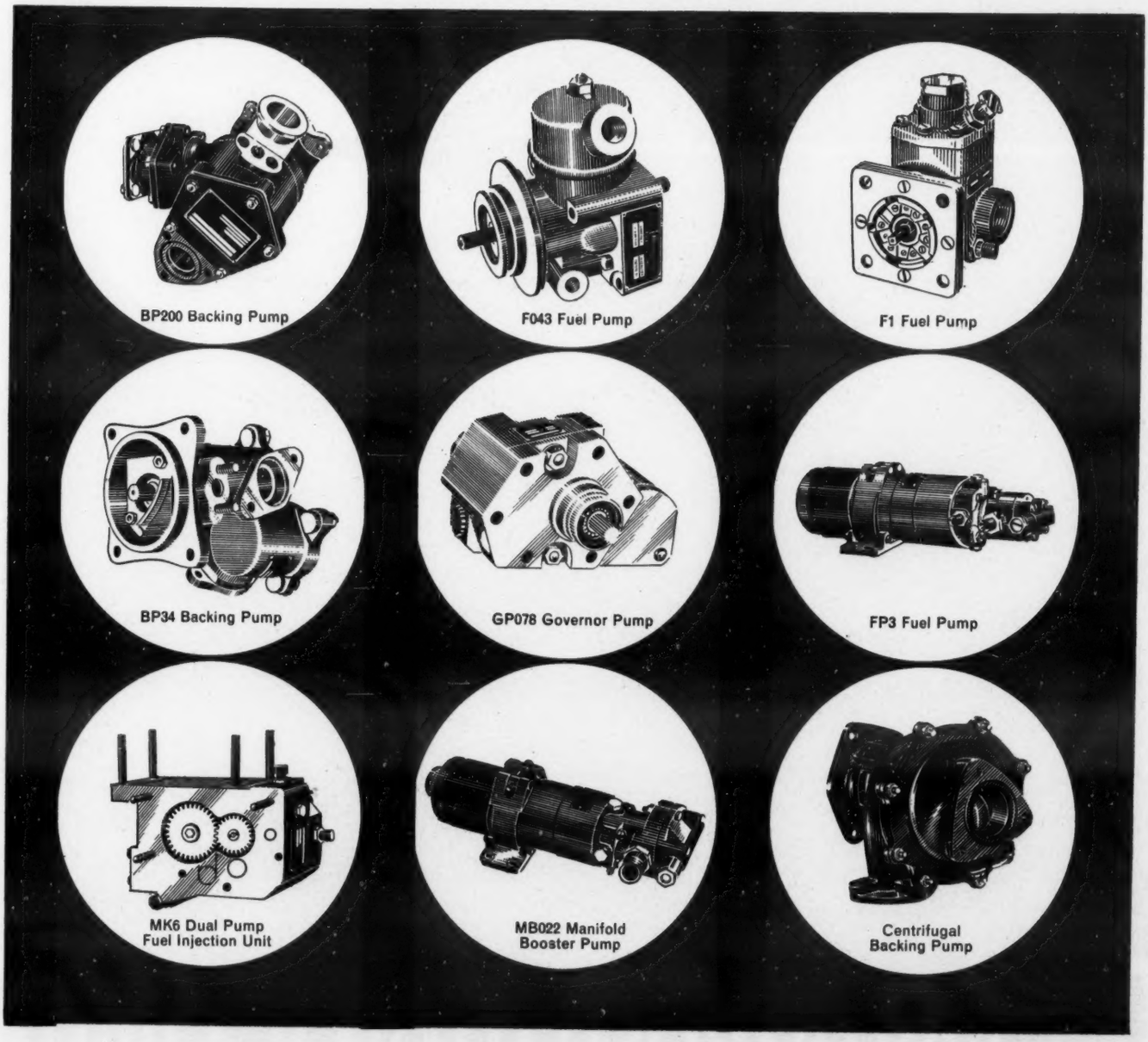
. . . they are all produced by Plessey, whose vast accumulation of experience in pump technology allied to the great resources for research and production which exist within the Company provides an unrivalled range of very advanced fuel pumps for the aircraft industry.

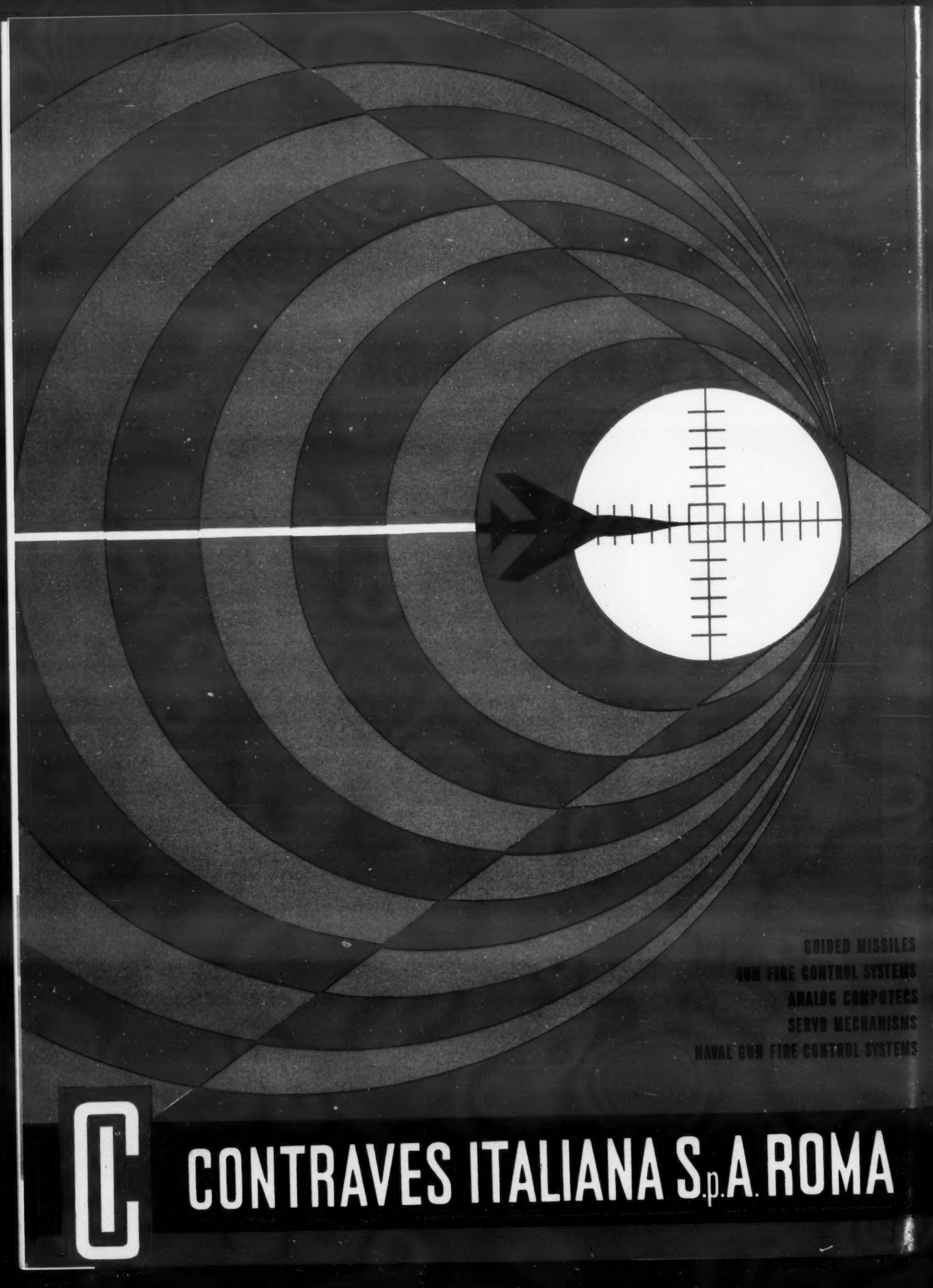
The overseas selling organisation of The Plessey Group of Companies

PLESSEY INTERNATIONAL LIMITED

ILFORD · ESSEX · ENGLAND

Overseas Telegrams: Plessinter · Telex · Ilford Telex: 23166 Telephone: Ilford 3040




GUIDED MISSILES
GUN FIRE CONTROL SYSTEMS
ANALOG COMPOTERS
SERVO MECHANISMS
NAVAL GUN FIRE CONTROL SYSTEMS
CONTRAVES ITALIANA S.p.A. ROMA

A PROVEN WEAPON SYSTEM NOW IN SERVICE

The SAAB J 35 Draken supersonic "double" delta-wing all-weather jet fighter has been in squadron service with the Royal Swedish Air Force since the beginning of 1960. One of the most modern jet fighters in service in the world today, the Draken has effectively proved its ability to intercept very fast targets during realistic Air Forces exercises. In fact, the Draken possesses a hitherto unmatched combination of high and low speed performance which makes it an extremely versatile fighting machine, able to operate from simple bases or stretches of straight road. The extremely short landing run — 600 m for normal operations — also reduces turn-round time between missions and vulnerability after landing as the aircraft can quickly go into shelters.

THE DRAKEN
and the weapon system in which it plays such an important role have considerably strengthened Sweden's air defence. Production of more advanced versions of the Draken weapon system is under way and further improved versions are now being developed.

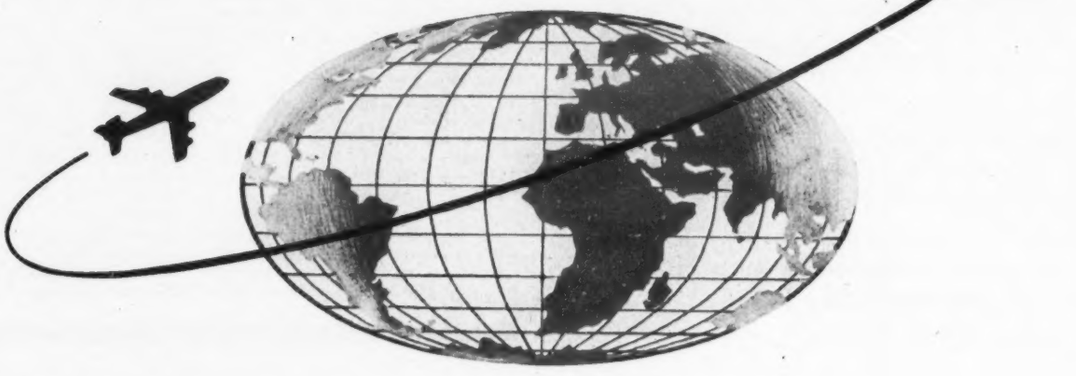
THE DRAKEN
35 B — has a more powerful Rolls-Royce engine and a Swedish afterburner delivering 25 percent more thrust than the 35 A power plant. This and other improvements have given the Draken a top speed of Mach 2 + and an initial climb rate of 50,000 ft. per minute. It is equipped with advanced collision-course fire control equipment and can carry either rocket and guided-missile fighter armament or heavy-attack armament, including rockets or bombs. A photographic reconnaissance version, fitted with a special camera pod, will also be produced. The 35 B is scheduled to go into service with the Swedish Air Force during 1961.

THE DRAKEN
has full radar and navigation equipment for all-weather operation.

THE DRAKEN
was designed and developed by SAAB — an enterprise with 10,000 employees. Production during the past decade includes well over 1,000 jet combat aircraft of four basic types for the Royal Swedish Air Force. SAAB is also a major producer of electronic equipment and motor cars.

SVENSKA AEROPLAN AKTIEBOLAGET *(SAAB AIRCRAFT COMPANY)* · LINKÖPING · SWEDEN

Around The World



Bendix

PROVIDES RELIABILITY

In the air, there is no substitute for the reliability factor which Bendix always engineers into a product. Bendix navigation systems . . . communications equipment . . . airframe and engine components are the finest made . . . providing performance compatible with the demands of today's jet aircraft. Bendix continually devotes its vast engineering resources and efforts to producing instrumentation to make flights more dependable and equipment more reliable.

Bendix International

Bendix

. . . IN COMMUNICATIONS

Bendix* VHF Radio Transmitters and Receivers • Interphone Systems • Audio Control Panels • Passenger Address Systems • Amspeakers* • Antennas • RF Power and VSWR Instruments

. . . IN NAVIGATION

Bendix Weather Radar • Doppler Navigation Systems • Helicopter Radar • Dead-reckoning Navigation Systems • Self-contained Integrated Navigation Systems for Military and Commercial Aircraft • Automatic Radio Compass Systems • Marker Beacon Receivers • VHF Omni-Range Equipment • VHF Ground Direction Finders • Glidescope Receivers • Microwave Equipment • Automatic Direction Finder Systems • Indicators • Automatic Pilot Systems • Central Air Data Computers • Polar Path* Compass • Supersonic Flight Control Systems.

. . . IN ENGINE COMPONENTS

Bendix Direct Injection Fuel Systems • Fuel Metering Systems • Jet Engine Analyzers for Temperature and Vibration • Carburetors • Fuel-Flow Totalizing Systems • Engine Starting Equipment • Magnetos • Ignition Analyzers • Ignition Systems • Electrical Connectors • Generators

. . . IN AIRFRAME PARTS

Bendix Hydraulic Actuating Equipment • Shock-absorbing Struts • Hydraulic Master Cylinders • Landing Gear—Wheels • Cerametalix* Brake Lining • Power Brake Valves • Rotor Type Brakes • De-Icer Systems • Anti-Skid Devices • Oxygen Systems

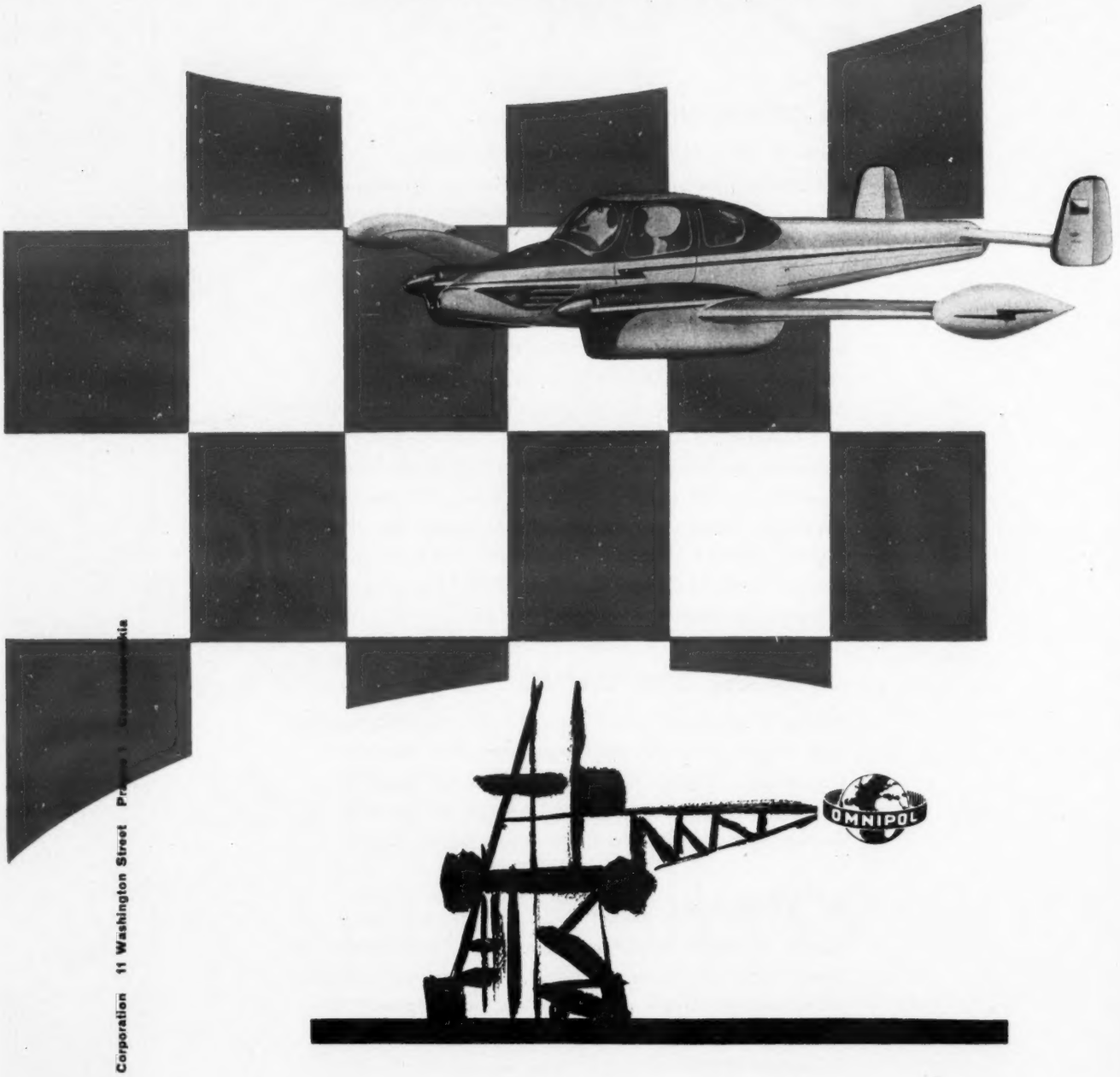
The part of Bendix in the transportation field is vast and varied. And because Bendix always anticipates aviation's next advance, almost every plane that flies relies on Bendix creative engineering and reliability in some way.

*Registered Trademark

Bendix International DIVISION

205 E. 42ND ST., NEW YORK 17, N.Y., U.S.A. CABLE ADDRESS: "BENDIXINT"

MORAVA L 200
WINGS OF COMMERCE



OMNIPOL Foreign Trade Corporation 11 Washington Street Prague I Czechoslovakia

- Aircraft for men of standing
- Aircraft for those who cannot be dependent on airline schedules
- Aircraft for those who must be able to go anywhere at any time
- Aircraft for travelling all over the world, comfortably and safely

Easy piloting, flight speed—280 km per hour, ceiling—6600 m, flight range—1700 km, fuel consumption—27 litres/100 km. 2 Walter M 337 motors with supercharger and direct fuel injection carry a pilot, four passengers and 110 kg of luggage on wings of *Morava*.

Agents: Argentina: Aeropat S.R.L., *Casilla de Correo 21*, San Fernando, Provincia Buenos Aires — Australia: Dulmison Aircraft Ltd., A.M.P. Building, *40, Miller Street*, North Sydney — Austria: Ing. Alfred Rutte, *Berggasse 16*, Wien IX — Belgium: Raymond Heuvelmans, *36, avenue Albert-Jonnart*, Bruxelles — Brazil: Cia. Latino Americana de material aeronáutico, *Rua dom Jose de Barros 17*, Sao Paulo — Chile: F. Speringer, *Av. 10 de Julio 1150*, Santiago de Chile — Colombia: Importadora Dantafé Ltada, Bogota. Denmark: Hammers Luftfahrt, *Vesterbrogade 54*, Kobenhavn — Federal German Republic: Aircraft G. Krautheim G.m.b.H., *Elsa Brandströmstr. 34*, Nürnberg — France: E.A.M., *46, rue Jacques-Dulud*, Neuilly-sur-Seine, Seine — Great Britain: Aircraft and General Finance Corporation Ltd., *3, Red Place, Green Street*, London W1 — Holland: R. Uges Jr. Esq., Handelsmaatschappij Het Oosten, *Thierenskade 27*, Rijswijk Z.H. — Iraq: The Engineering and Commercial Services W.L.L., Baghdad — Spain: Suministros Industriales Meyer, *Av. José-Antonio 76*, Madrid — Switzerland: Edwin Ott, *Oerlikonerstr. 27*, Zürich.

Something new in VHF... from Paris

ER-144 Transceiver — Power supply and modulator unit

First quality equipment,

	low price
Public transport version	
ER-144 (360 Channels), 100 kc/s spacing, supplied with 280 frequencies : 108,0 to 135,9 Mc/s . .	**1.319 $**
ER-144 C (720 Channels), 50 kc/s spacing, supplied with 560 Frequencies : 108,0 to 135,95 Mc/s . .	**1.521 $**
ER-144 D (720 Channels), 50 kc/s spacing, supplied with 560 Frequencies : 108,0 to 135,95 Mc/s . .	**1.856 $**
Aero-Club version	
ER-144.1 — 100 kc/s spacing, supplied with 60 Frequencies : 118,0 to 123,9 Mc/s	**977 $**
ER-144.2 — 50 kc/s spacing, supplied with 120 Frequencies : 118,0 to 123,9 Mc/s	**1.180 $**

■ **Meets IFR requirements for air traffic in the 1960s**
Combining in a single, easily maintained unit all functions VHF-1, VHF-2 and navigation receiver.

■ **ER-144 transceiver**
Providing 360 or 720 channels operation
designed according to the new IFR specifications of the "Service de la Navigation Aérienne" and American TSO-FAA regulations, solves all your problems for modern air traffic

■ **No more problems with crystals**
They are supplied as an integral part of the frequency standard stage included in transceiver assy.

■ **In the extra-wide 108 to 144 Mc/s band**
You can select any transmission or reception frequency automatically tuned by simple switching of digital tuner.

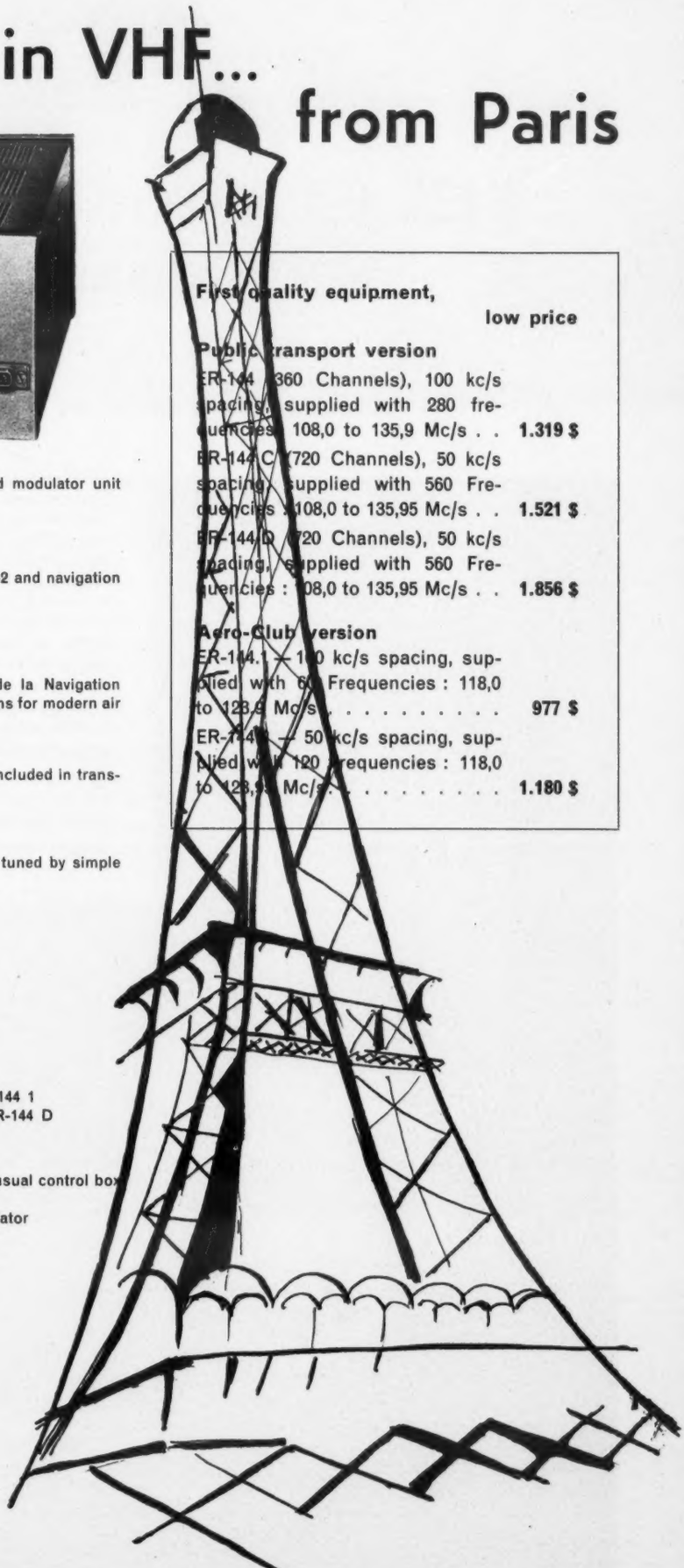
■ **VOR or ILS reception**
is immediately available by switching a VHF/VOR/ILS relay.

Practical operating range-exceeding 90 miles at 3.000 feet
with 6-8 Watts minimum output — on ER-144 — ER-144 C models
and 12-15 Watts minimum output — on ER-144 A — ER-144 D models.
All models have same dimensions and are interchangeable.

Channel spacing 100 Kc/s steps for ER-144 — ER-144 A — ER-144 1
50 Kc/s steps for ER-144 2 — ER-144 C — ER-144 D
with high selectivity.

Miniaturized edge-lighted units
occupying the same space on instrument panel or cockpit coaming as usual control box with standard FAA-NATO-BNAé attachments.
Total weight : 8½ pounds including : transceiver, power supply, modulator

Low input power : less than 100 Watts
7 Amps. at 14 Volts
3,5 Amps. at 28 Volts
Built according to military standards
Reliability at extreme temperatures conditions and under tropical climates
Carries a one year warranty



DESIGNED AND PRODUCED BY

AVIRADIO

40, rue Ernest-Renan — ISSY-LES-MOULINEAUX (Seine)
Telephone : MIChelet 20-16 — Cables : AVIRADIO PARIS

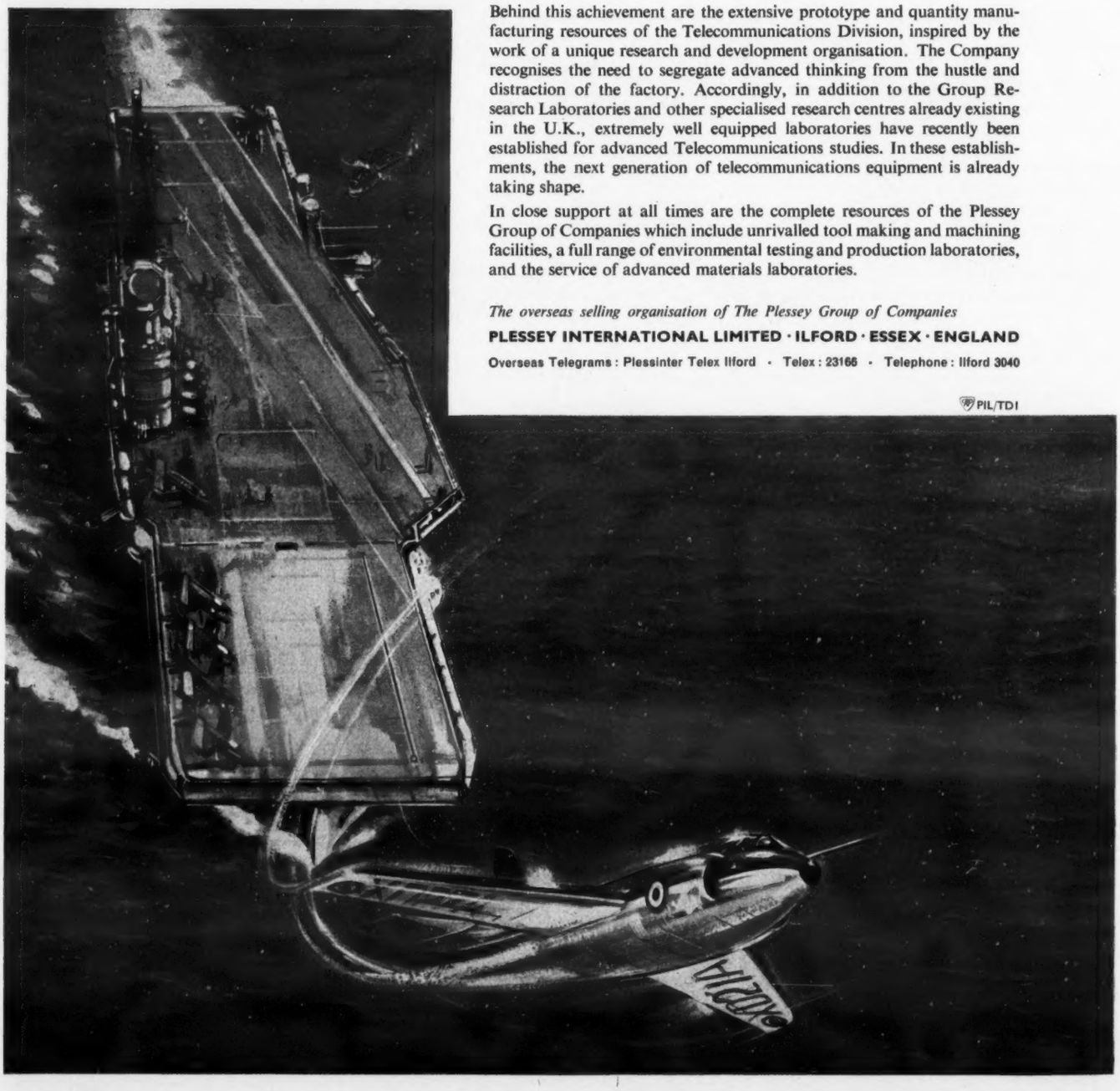
Specialists in American military equipment - Radio service stations at TOUSSUS and ISSY, for aircraft installations - Guarantee - Maintenance - Repairs - Modifications

Plessey

TELECOMMUNICATIONS

'clear the air'

Plessey is everywhere, you'll find . . . in the Royal Navy for example, where strike aircraft of the Fleet keep a watching brief on the skyways and maintain contact with the help of Plessey UHF.



Behind this achievement are the extensive prototype and quantity manufacturing resources of the Telecommunications Division, inspired by the work of a unique research and development organisation. The Company recognises the need to segregate advanced thinking from the hustle and distraction of the factory. Accordingly, in addition to the Group Research Laboratories and other specialised research centres already existing in the U.K., extremely well equipped laboratories have recently been established for advanced Telecommunications studies. In these establishments, the next generation of telecommunications equipment is already taking shape.

In close support at all times are the complete resources of the Plessey Group of Companies which include unrivalled tool making and machining facilities, a full range of environmental testing and production laboratories, and the service of advanced materials laboratories.

The overseas selling organisation of The Plessey Group of Companies

PLESSEY INTERNATIONAL LIMITED · ILFORD · ESSEX · ENGLAND

Overseas Telegrams : Plessinter Telex Ilford · Telex : 23165 · Telephone : Ilford 3040

PIL/TDI

The Changing Face of an Airport

Frankfurt am Main, a Centre of Jet Operations

By K. Prochazka, Interavia, Geneva

On November 29th last year, Frankfurt am Main Airport was the first in Germany to record its two millionth passenger in one calendar year, thus claiming third place (after London and Paris) in the list of European airports which have exceeded the two-million mark.

This record, which has been achieved ten years after responsibility for transport was placed in German hands, is most impressive, for Frankfurt has increased its passenger volume tenfold in the past ten years despite the fact that, unlike the other leading airport cities of Europe, it is neither a seat of government nor a large metropolis. In other words, the number of passengers has risen by an annual average of 25 percent—a rate of growth far above the world average.

No less impressive is the increase in the number of airlines running scheduled services to Frankfurt. In 1950 seven airlines routed their services via Frankfurt; today the airport is served by 36 scheduled carriers from five continents, plus half a dozen charter operators. Not even the transition from the summer timetable to the normally less dense winter schedule has halted the rapid upward trend. For the first time, the winter timetable records a higher number of aircraft movements than that of the preceding summer. This is all the more surprising as the placing in service of jet aircraft generally causes a drop in the number of aircraft movements. (Airport passenger volume continues to rise, however, as the seating capacity of the jets is considerably greater than that of their propeller-driven predecessors).

At the present time, every fifth aircraft making a scheduled landing at Frankfurt is a jet, and almost half the 36 airlines have already included the airport in their jet route networks.

Rapid as has been the increase in passenger volume at Frankfurt Airport, it has been set in the shade by the boom in the air freight business—often described as commercial aviation's "second string." From 1958 to 1959 the freight turnover rose by no less than 46 percent, i. e., more than three times the world average (the figures for 1960 had not yet been published as these lines went to print). The number of weekly scheduled take-offs and landings of pure freight aircraft this year has increased by 50 percent over the figure for last winter.

The significance which the Frankfurt Airport administration accords to air freight is clearly evident in the immense building site at the western end of the present terminal area, where a new freight building is in course of construction. The new building, which is next to the present air freight facility, will have storage and office areas of 112,000 sq. ft., thereby more than doubling the present freight capacity. The functional design of the new building, whose four storeys (basement, ground floor and two upper floors) are served by goods lifts, provides the basis for more rapid customs clearance. Lufthansa will fit its part of the building with a "home-designed" installation (which will increase its storage area by one third) to enable it to achieve flexibility in freight handling. The building is scheduled for completion in late summer this year. After its extension, the Frankfurt air freight facility will be able to handle up to 90,000 tons of freight a year, a quantity which, according to the latest estimates, is to be expected in about 1966. The "live goods" passing through Frankfurt Airport are, however, inclined to grudge the pride of place given to freight in the extension plan, when they have been shunted back and forth a few times through the passenger terminal building . . .

Apart from its terminal building, which it is now outgrowing, Frankfurt Airport is relatively well equipped to meet the exacting demands of the jet age. It was realized in good time that the provision of adequate runways and taxiways was essential if jet aircraft were to operate at the airport, and the extension of these facilities was therefore given priority over all other projects. Today Frankfurt has a main runway 11,880 ft long and 200 ft wide, with a parallel runway 1,710 ft to the south measuring 9,900 × 148 ft. Both runways have 990 ft overshoot areas to the west, the main direction of approach being from the east, and can accept wheel loadings of up to 99,000 lb.

The men who run Frankfurt Airport. Left to right: Rudolf Lange, Director and Technical Manager of Flughafen Frankfurt/Main AG (FAG); Walter Luz, Director and FAG Commercial Manager; Hans Süssenguth, a Director of Lufthansa, responsible for all airport traffic operations and Lufthansa's new maintenance depot at Frankfurt; Air Traffic Control Director Neumann.

The new Telefunken long-range surveillance radar on the Neunkirchner Höhe, 25 miles south of the airport, with a range of 120 nautical miles and an altitude coverage of 31,000 ft; wavelength 23 cm. Operational trials are scheduled to begin in May this year. Radar data are transmitted by a Philips wide-band directional radio system to the area control centre at Frankfurt/Main.

Among the landmarks of the airport is the tower with the ASR-3 airport surveillance radar. The installation, built by Telefunken under licence from Bendix, will shortly be converted and partially adapted to meet the specifications for ASR-4 installations; the main aim of the conversion work will be to treble the altitude coverage, which is at present 10,000 ft.

The Decca 41A weather radar can detect clouds and zones of precipitation up to a distance of about 200 miles. As the trial run last summer was satisfactory, the equipment is being prepared for regular operation. Telefunken is responsible for the installation work.

As the airport altitude is 340 ft above sea level and the average midday temperature during the hottest month of the year is 79 °F, the main runway should be adequate for all the requirements of even the largest jet aircraft at present in service. The temperature over the runway in summer has, however, been known to reach almost 104 °F when the wind is blowing from the east. As aircraft take off on long North Atlantic flights mostly during the hot hours of the early afternoon, it is planned to extend the main runway to 12,870 ft towards the west. As if this were not enough, the desirability of a third runway is under investigation; this could run in a north-south direction to the west of the present airport territory. It would be used solely for take-offs in a southerly direction, as landings from the north and northward take-offs are impossible owing to the presence of the Taunus mountains, which in some cases reach heights of around 3,000 ft. Landings from the south would require the adoption of a complicated missed approach procedure and the installation of costly approach aids. Moreover, all such flights would lead over the town and would sorely tax the ear-drums of the population.

Theoretically, neither the utilization factor of the airport nor its capacity would be improved by the construction of a third runway. In the special case of Frankfurt, however, the possibility of taking off southwards would have certain advantages from the air traffic control point of view, and these might warrant the third runway.

Urgently needed . . . a new terminal building

Although, as regards runways and taxiways, Frankfurt can face the steadily increasing jet traffic with confidence, there is already the threat of congestion in the terminal area. Admittedly, the apron has been enlarged several times in recent years and equipped with outside stands for jet aircraft. Esso has built an underground refuelling installation with hydrants, which is supplemented by modern large-capacity refuelling trucks built by Ad. Strüver, KG. The terminal building, too, has been repeatedly enlarged. All these makeshift solutions do not, however, conceal the fact that the building will soon reach the limits of its capacity. From the functional viewpoint, too, the building is no longer suited to present-day requirements. It is all too easy for the traveller, particularly the transit passenger, to lose his way, and he has the impression of making unnecessary detours. The architects responsible for the design have undoubtedly done their best, but the development potentialities of even the best design have their limits.

As it is likely to be some time before the new terminal building is completed, the old building has been given a new lease of life—probably its last—in the form of a semi-automatic baggage conveyor system, which was put into operation step by step as the installation proceeded and is now nearing completion. All baggage items are collected and sorted in a hall recently built in front of the terminal building. Baggage is transported between the aircraft and this hall by conventional carts or special baggage vehicles. The latter can carry around 2 tons of baggage or small freight items and are fitted with a conveyor belt whose level and inclination are adjustable. The vehicle, which was developed by Maschinenfabrik Esslingen in close cooperation with the airport, can be operated by one man. Baggage vehicles will no longer have to enter the terminal building.

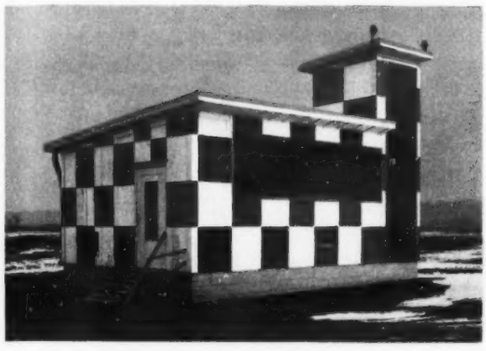
After the baggage is weighed and checked in, the official places it on a conveyor belt passing behind him. A series of belts transports the baggage to the baggage hall, where it is pushed into one of 16 collector boxes by an electronically controlled deflector. Each box corresponds to a specific departure. The "helmsman" at the head of the row of boxes looks at the baggage rag, which tells him where the suitcase belongs, and records the number of the box as the baggage passes the control point. The number is stored and releases the pneumatic deflector when the baggage reaches the appropriate box.

Arriving baggage is sorted in the baggage hall. Baggage from international flights is sent by conveyor belt to the customs hall, where it is guided by an operator into a box. The passenger takes his baggage himself and passes through the customs. There is a separate band for domestic baggage, leading to ten boxes in the domestic arrival lounge.

The installation of the baggage conveyor system in a building of such complex design as the terminal made the paths taken by the conveyor belts very complicated and necessitated frequent changes in level and direction. It was therefore no wonder that the system developed certain teething troubles which were, however, easily

overcome. For instance, the original conveyor belts, which were 26 inches wide, were found to be too narrow and had to be replaced by 32 inch belts. Many rises had to be levelled out; for with an inclination of more than 15 percent the baggage is likely to slip backwards on the belt. The numerous deviations required the installation of sprung guide plates and similar devices. Each band will support 60 lb per yard and can transport

The airport control tower ▶ is being completely refashioned. The ground plan of the lower storeys will be rectangular, and these floors will accommodate some of the air traffic control quarters now housed in the terminal building. Completion is scheduled for this year. A new terminal building with fingers is to be built around the control tower.



◀ The Telefunken precision approach radar (built partially under licence from Bendix), at present covering runway 25R, will probably be moved to the southern runway, while the main runway will have an advanced version of the PAR-2, which can be used to control both directions of approach. The latter is doubtless similar to the radar which Telefunken is now installing at Munich.

up to 1,800 baggage items per hour. The maximum dimensions of the items to be transported are 32 in. long, 32 in. high, and 17 in. wide. The conveyor system, which was built by Fredenhagen KG at a cost of about DM 1 million ($238,000), not only reduces congestion in the old terminal building, but also enables experience to be gained for the system to be installed in the new building.

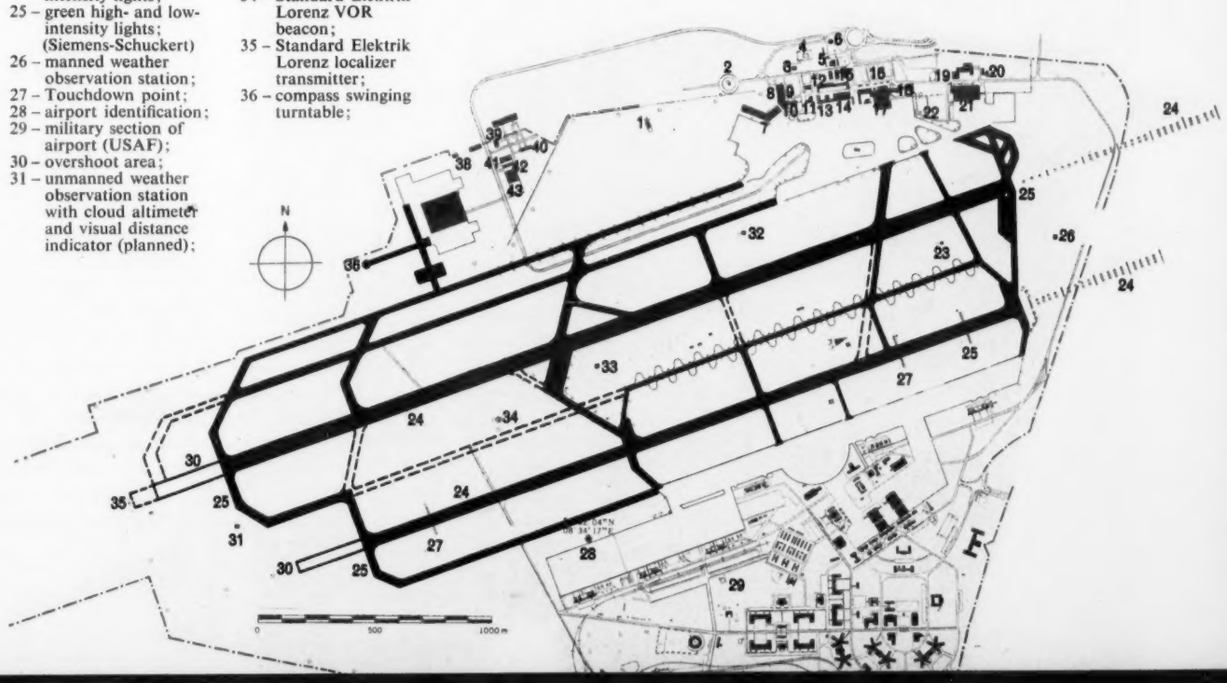
The latter will be situated to the west of the present terminal area. A number of designs have been submitted and rejected during recent years, but the most recent proposal seems to have good prospects of realization. Airport Technical Manager Lange gave the writer a detailed explanation of the design of the planned facility (see layout on the last page of the present article). The plan makes provision for 36 aircraft stands at the final phase of construction; these will be grouped at the end of a number of boarding fingers. Each stand will have hydrants for fuel, a. c. and d. c., compressed air and water. Passengers will have to walk only a few steps in the open air from the soundproof gate lounges to the aircraft. These gate lounges will be so designed that they can be fitted with covered passenger bridges at a later date. All aircraft will be able to manoeuvre under their own power.

Passengers will be cleared on the upper floor of the centre section of the building. It will probably be decided to adopt a system of desks which can be hired out to airlines in rotation, as and when required. Conveyor belts will take the baggage from the airline desks to a central collecting room on the ground floor, whence it will be taken to the aircraft by special vehicles. Incoming baggage, too, will pass through the collecting room and be sent by conveyor belt to boxes in the arrival lounge on the ground floor.

As a considerable number of passengers using Frankfurt Airport are in transit, it is not advisable to relegate domestic traffic to a separate building

Layout of Frankfurt/Main Airport. Existing runways and taxiways are shown in black, planned taxiways are outlined. The northern runway will shortly be extended to 12,870 ft by building over the 990 ft overshoot area.

1 – control tower, later to form the centre of the new terminal building;
2 – radar tower with Telefunken ASR-3 airport surveillance radar;
3 – transformer station and emergency power supply; (Ad. Strüver KG)
4 – building yard;
5 – garages;
6 – Decca 41A weather radar;
7 – freight store (undergoing extension);
8 – freight offices;
9 – airport administration building;
10 – firefighting service;
11 – refuelling service building;
12 – workshops and canteen;
13 – storerooms and workshops;
14 – aircraft maintenance hangar I;
15 – air mail building;
16 – car park;
17 – terminal building;
18 – café terrace;
19 – exhibition hall, cinema;
20 – office block;
21 – aircraft maintenance hangar II;
22 – visitors' area;
23 – Standard Elektrik Lorenz glide path transmitter;
24 – white high- and low-intensity lights;
25 – green high- and low-intensity lights; (Siemens-Schuckert)
26 – manned weather observation station;
27 – Touchdown point;
28 – airport identification;
29 – military section of airport (USAF);
30 – overshoot area;
31 – unmanned weather observation station with cloud altimeter and visual distance indicator (planned);
32 – Telefunken precision approach radar;
33 – Rohde & Schwarz visual direction finder;
34 – Standard Elektrik Lorenz VOR beacon;
35 – Standard Elektrik Lorenz localizer transmitter;
36 – compass swinging turntable;
37 – hangar of Lufthansa maintenance depot;
38 – heating plant for maintenance depot;
39 – Lufthansa simulator building;
40 – Lufthansa administrative office block;
41 – canteen;
42 – airfield equipment workshop;
43 – apron services.



or wing, as this would mean a long walk for many. Domestic and international passengers will be cleared on the same floor of the same building, being separated from each other only by channels.

The new building was planned on the basis of an estimated six million passengers a year. If traffic volume grows beyond this figure, it would be possible to build a satellite station to the south of the two runways; this could be connected with the terminal building by tunnel. A project of this magnitude naturally requires facilities for traffic coming from the town. A garage with four floors, of which two are underground, is on the general extension programme, together with a new airport access road with a three-level fly-over connection to the motor road.

Ambitious as the programme may seem, Commercial Manager Walter Luz hopes to complete it without subsidies from public funds. He points with satisfaction to his balance sheets, which are still in the black despite the investments made in recent years. The airport extension is being financed partly out of the operating company's own means and partly from loans from shareholders or third parties. Luz emphasizes that shareholders' loans carry a very low rate of interest and are therefore not speculative investments.

Ambitious ATC projects

Frankfurt lies at a vital junction point for air traffic, for no less than nine main air routes converge on it. It is therefore not surprising that air traffic control in the Frankfurt area is beset by particular problems, which are not in any way relieved by the mixed civil and military operations at the airport itself, a number of military bases nearby, and the presence of the Taunus mountains to the north. It is easy to see why the Bundesanstalt für Flugsicherung (Federal Institute of Air Traffic Control)—whose headquarters are in the city of Frankfurt—maintains its largest unit at Frankfurt Airport.

The airport and approach control service has been working on the new "semi-finished" control tower since 1957. On completion of the tower, which is scheduled for some time this year, further air traffic control departments will be able to move from the present terminal building to more modern quarters.

The high fuel consumption of jet aircraft requires a rapid climb to cruising altitude after take-off. The main take-off direction for jet traffic is the west—the very direction in which aircraft must be routed through the densest traffic. This requires coordination of departure, climb and routing clearances among four to six air traffic control points. Only the extensive use of radar can remedy this situation.

Telefunken recently set up a long-range radar surveillance antenna on the Neunkirchner Höhe, 25 miles south of the airport; the system works on the L-band (23 cm), with an altitude coverage of 31,000 ft and a range of 120 nautical miles. Calibration trials are to begin in March this year, and the operational trial run should begin in May unless unforeseen difficulties occur. Radar information (normal video, MTI video and antenna azimuth data) will be transmitted to the airport control centre by a Philips 7,000 Mc/s wide-band radio link. The new radar will replace the CPS-5 mounted on the terminal building, an older equipment which has been placed at the disposal of the

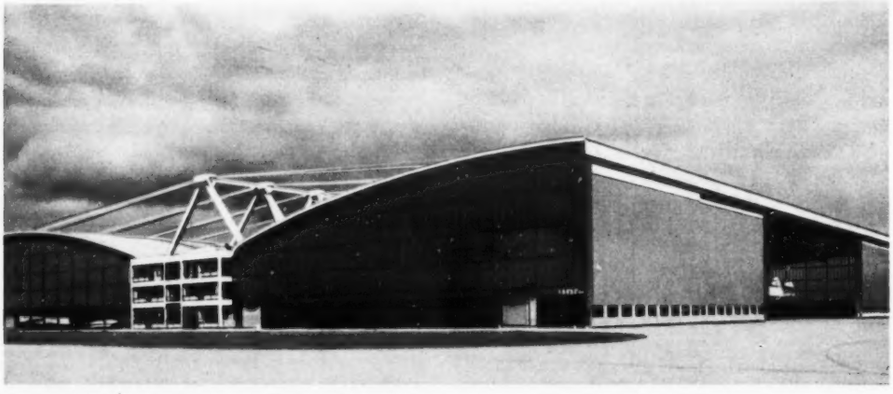
Approach control centre with Telefunken radar displays and Siemens & Halske control consoles.

Bundesanstalt für Flugsicherung by the U.S. Air Force. It is also planned to set up a Rohde & Schwarz wide-base direction finder on the Neunkirchner Höhe; the information from this will likewise be transmitted to the control centre by radio link.

Under the air traffic control modernization programme, the control centre will move out of the cramped terminal building. The Bundesanstalt will probably build an "air traffic control village" to the north of the motor road, i.e., outside the present airport boundary; the telecommunications centre and parts of the technical service and administration would also be transferred to this location. The long-desired integration with "Rhine-Control," the upper airspace control centre, would then be possible.

The Munich area control centre is on the point of being abolished and will be incorporated in its entirety in the Frankfurt centre, which already controls two sectors formerly in the territory of Munich. This means that the information from the long-range radar at Munich will have to be transmitted to Frankfurt. Possible methods of long-range transmission are at present under investigation, the best solution apparently being narrow-band transmission via radio link.

The increasing congestion in German airspace and the lack of qualified air traffic controllers is forcing the Bundesanstalt für Flugsicherung to improve upon the conventional time-wasting control procedures as quickly as possible and turn to high-performance automatic systems. At the beginning of 1962 Telefunken will deliver a



Lufthansa's new maintenance hangars have a capacity of nearly 12½ million cu.ft. The two hangars, which are 550 ft long and 180 ft wide, can each accommodate three large jet aircraft (four if parked diagonally) or four to six propeller aircraft. The concrete roof shells, which are only 3 to 5 in. thick, rest on the central structure and are held in place externally by 96 forty-strand steel cables, which in their turn are anchored in central pylons. The doors can be slid into any position so as to leave up to 60 percent of the hangar open at any given time. A telescopic fixture above the doors will absorb upward and downward movements of the roof to the extent of 3 ft.

TR 4 electronic computer which, in conjunction with automatic tape-printers, should make a decisive contribution towards relieving the controller's task. Later, the computer will process information from Hanover control centre and retransmit the appropriate data. At the same time, the opportunity will arise to investigate various data transmission methods, develop operators' consoles and test various forms of air situation presentation. It may even be possible to work out effective methods of traffic conflict indication.

The second stage of the modernization programme makes provision for the automation of all operators' positions. By then the new centre in the air traffic control village will be ready. Also on the programme are the exchange of data with neighbouring countries and tasks such as calculation of the most favourable flight paths.

In the third stage, radar information will also be incorporated in the system. In the fourth stage, data links for air/ground automatic communications will be introduced (e.g., regular reporting of flight altitude); this will, of course, require international agreements on the equipment to be carried by commercial aircraft.

The Telefunken/Bendix ASR-3 airport surveillance radar, which has already been in operation for some time, is to be converted and partially adapted to the specifications for ASR-4 installations. For this purpose it will have a new antenna which will increase altitude coverage from 10,000 to 30,000 ft. A circular polarization system and a new antenna gearbox for two rotation speeds (12 and 24 rpm) will also be provided.

If the airport is not to be the weakest link in the air traffic control system, a series of high-performance landing aids must be installed. The only complete approach system at present in service, consisting of ILS, PAR and Calvert approach lighting, is installed on runway 25R. A second Calvert lighting system is at the east of the southern runway. It is planned to equip the northern runway (07L/25R) for instrument landing in both directions, and to provide the southern runway (07R/25L) with complete equipment for approaches from the east. The PAR at present covering the main runway will accordingly be transferred to the southern runway and replaced by a PAR-2 equipment. This will presumably be similar to that recently installed by Telefunken at Munich-Riem. In the PAR-2 the whole antenna array can be slewed, so that a single radar suffices for a number of directions of approach. In the case of Frankfurt, the radar could cover both directions of the main runway.

Finally, the 2½ miles of runways with their many crossings require an airfield surface movement radar with high discrimination; indeed, the air traffic controllers feel that two of these radars would be even better than one.

After the airport extension programme is complete, the airport and approach control service hopes to achieve a total of 60 to 65 movements per hour under instrument flying conditions. Despite the fact that the runways are only 1,710 ft apart, it is quite possible to use both for simultaneous landings, provided that aircraft during final approach are three to four miles apart. On the northern runway alone, thirty movements per hour have been achieved for a period of 1½ hours, with a visibility of only two or three miles. ILS approaches were initiated with the aid of the ASR-3 and then monitored by GCA.

By day or night, activity in Lufthansa's modern apron service building never ceases. Here in addition to food, everything needed for passenger comfort—linen, reading matter, children's toys and articles for sale—is prepared in accordance with a plan worked out down to the smallest detail.

The German meteorological service is loth to lag behind the air traffic control service. Dr. Brinkmann, Director of the Frankfurt am Main air meteorological station, is very proud of his latest acquisition, the Decca 41A weather radar, which was erected last year by Telefunken on a slender steel tower. The radar will detect clouds and zones of precipitation at distances of up to about 200 miles. The antenna tilt can be varied so that weather phenomena are partially recognizable from their vertical extent. The equipment is the first of its kind in Germany to be designed specially for airport meteorological purposes. The trial run in summer, 1960 was so satisfactory that the equipment is now being prepared for continuous operation.

Among the projects of the meteorological service is a new observation station which can be sunk hydraulically into the ground. The idea for this unusual facility, which enables the observer

Next to the existing air freight store, work is going ahead on a four-storey freight building with a floor area of nearly 112,000 sq.ft., which will more than double the capacity of the freight facilities. The radar tower can be seen on the right, the control tower on the left and the Lufthansa office block at far left.

At a cost of about 1 million DM ($238,000), Fredenhagen KG, of Offenbach, is installing a semi-automatic baggage conveyor system in the terminal building. The experience gained here, under difficult conditions, will serve as a basis for a similar installation which is planned for the new terminal building. After being weighed and checked in at the airline desks, the baggage travels along a chain of conveyor belts into a hall on the airport apron, where it is placed in boxes by centrally controlled pneumatic levers. The procedure is reversed for arriving baggage, which is first divided into domestic and international baggage and then sent in boxes to the arrival lounge.

to withdraw below ground in an emergency, stems from an accident which occurred years ago, when an observer was killed at his post by a crash-landing jet fighter.

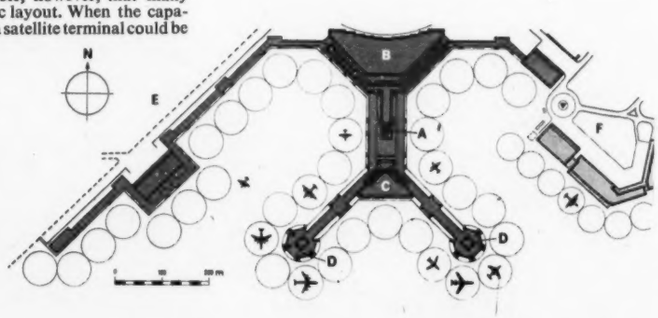
A Siemens-Schuckert cloud altimeter to the east of the main runway will be supplemented by a second at the western border of the airport, where the prevailing conditions are often substantially different from those in the east. At present, trials with runway visual range indicators are in progress; here it is essential to have a row of lights which can enable the pilot to judge distances. The meteorological service, too, wants its share in the blessings of automation. At present the weather station sends reports by teleprinter every half hour to the air traffic service, which processes and broadcasts them. From the middle of this year the observer will record the text of the weather reports directly, the recordings then being played back over the transmitter (meteorological frequency). The necessary equipment has been developed by Wolfgang Assmann GmbH to ICAO recommendations.

New Lufthansa maintenance centre

If, after entering the airport, one turns right into a quiet shady road, one comes, rather surprisingly, on a group of scattered buildings. Two of them at once catch the eye: an eight-storey block of reinforced concrete, whose austerity is mitigated only by the artificial stone facing and a few awnings; and a giant building with a silhouette like a butterfly which, even to one having no knowledge of the location, is easily recognizable as an aircraft hangar. Since October last year, the eight-storey building has been the headquarters of Hans Süssenguth, a Director of Lufthansa and responsible for all the airline's traffic operations. Facing the writer across the table of his Spartan office, Süssenguth summarized the many tasks of the new Lufthansa centre, which employs about 500.

As the point of departure for many of Lufthansa's important routes, Frankfurt is the obvious choice for the facilities directly connected with flight operations: operational planning, apron service, ground service (which ensures that aircraft stands are properly equipped) and telecommunications service. Of all German airports, Frankfurt am Main is the best equipped for jet traffic and, says Süssenguth, will remain so... one more argument for setting up the jet aircraft maintenance centre here. Moreover, he adds, Frankfurt has enough land for large building projects, with plenty of scope for later extensions.

Ground plan of the new terminal building, which is designed to handle 6 million passengers a year. This is only a preliminary design and is likely to undergo a number of modifications. It is improbable, however, that many changes will be made in the basic layout. When the capacity of the building is exhausted, a satellite terminal could be built south of the two runways; this would be linked with the main building by tunnel. A – control tower; B – passenger lounge; C – transit lounge; D – fingers with gates, later to be equipped with covered loading bridges; E – west wing, planned for the second extension phase; F – freight building, at present undergoing extension.



On the subject of handling problems, Süssenguth expressed his dissatisfaction with a number of trends. He would like, for instance, to see passenger handling at all airports in the hands of the airlines, whose personnel are generally far better trained in customer service than the "neutral" airport employees. Süssenguth mentions that Lufthansa is developing handling methods in its own sphere of activity – from the check-in service to apron equipment and freight processing – and has already made considerable progress.

On a tour of the facilities the writer was able to admire the generous lines on which the installation has been planned. The airport operating company commissioned the facilities and lets them to Lufthansa. After a brief visit to the simulator building, where Lufthansa pilots are trained for service on the Boeing 707, we entered the maintenance hangar, whose advanced design has aroused the admiration of all civil engineers. With a clear height of 51.5 ft at the doors, the hangar should be well able to accommodate any future aircraft type. Floor heating, strip lighting in the reinforced concrete roof and glazed sides ensure pleasant working conditions.

Since March, 1960, the man-hours spent on the maintenance and overhaul of Lufthansa's Boeing 707-430s have been cut by half. Thanks to a comprehensive communications system and meticulous flight planning, the utilization of the Boeing fleet has been gratifyingly high, up to 10½ hours daily. All airports served by Lufthansa's Boeing 707-430s and Lockheed 1649As are in teleprinter contact with Frankfurt, so that workshops obtain advance information of work they are likely to be called upon to perform and can make the necessary preparations. Defects occurring in flight are reported by pilots over the radio.

The apron service building is a veritable hive of industry, and its facilities cannot fail to fascinate any visitor: bakery, butchery, sausage factory, meat kitchen, deep-freeze installations for 0° F and –40° F, a vast food store in the basement, laundry for cabin linen and many more. Attached to the building are a canteen and a passenger room where Lufthansa serves original cabin meals. The writer's palate convinced him that the many diplomas and certificates hanging in the entrance hall had more than a mere paper value.

It would be strange if the many interests represented at the airport did not have occasional differences of opinion as regards planning and operation. But conversations with those concerned show that all have one common aim: to make Frankfurt am Main Airport an efficient and exemplary centre of jet operations.

In conclusion, the writer would like to thank Messrs. Lange, Luz and Süssenguth, Dr. Heer, President of the Bundesanstalt für Flugsicherung, Dr. Brinkmann and all their colleagues for the warm reception he was given. ←→

Rockets, Missiles and Space Vehicles

A new version of the Martin Pershing *tactical surface-to-surface guided missile (cf.* Interavia *No. 11/1960, p. 1410) being fired from a mobile erector/launcher. The total value of U.S. Army orders for* Pershings *placed during fiscal 1961 alone amounts to over $138 million, including a recent order valued at almost $77 million.*

Project Mercury

An unmanned *Mercury* space capsule was launched by *Redstone* booster from Cape Canaveral missile firing range on December 19th, 1960. The capsule, which was fully instrumented, was recovered unharmed from the Atlantic after a flight of about 200 miles; it had reached a maximum altitude of about 130 miles.

This launching, the first in which the capsule ejection mechanism worked successfully, was preceded by two failures. On November 8th a *Mercury* capsule fired from NASA's Wallops Island research station failed to separate from its *Little John* booster; and a further attempt from Cape Canaveral on November 21st, when a rocket in the capsule recovery device fired unexpectedly a few seconds before the *Redstone* booster was launched and tore away the escape tower, was also unsuccessful.

The seven *Mercury* astronauts have completed another centrifuge training programme at the U.S. Navy's Aviation Medical Acceleration Laboratory at Johnsville, Pa. During training they were subjected to accelerations equivalent to those which they will encounter during the *Redstone* sub-orbital flights which are scheduled to take place early this year. The *Redstone* flights were simulated as realistically as possible. All the ground support equipment which will be needed for the actual firing was used, including a special trailer for transporting the astronaut to the launching site and medical monitoring consoles for keeping a check on his physical condition. During each training session in the Acceleration Laboratory, which lasts for an average seven hours, astronauts are subjected to five 15-minute dynamic runs and three static runs. During the tests medical data were recorded, and the sessions were followed by a thorough medical inspection of the pilots and discussions on their behaviour and impressions.

The centrifuge was fitted with special devices to simulate failures in the *Mercury* capsule's automatic stabilization and control system. In such cases the astronaut took over control himself. The centrifuge at Johnsville, whose two-gimballed gondola is fixed to a 50 ft boom, can reach accelerations of up to 40 g. The seven astronauts have withstood as many as 16 g, about the maximum which would be encountered in a *Mercury* flight. Is was also found that all the astronauts could take steps to improve their ability to withstand high accelerations.

The projected cost of the *Mercury* programme could exceed $500 million, according to a preliminary progress report by the House of Representatives Science and Astronautics Committee. Commitments for *Mercury* up to June 30th, 1961, are as follows; $240.3 million for research and development and $53.2 million for construction. NASA estimates that an additional $100 million will be required to complete the project.

Tiros 2 launching

The following additional details of the launching of the NASA *Tiros 2* weather satellite by *Thor-Delta* booster (cf. *Interavia* 1/1961, page 98), have been released. The first stage fired for 158 seconds after launch from Cape Canaveral. Four seconds later, after separation of the first stage, the second stage fired and burned for 109 seconds before being shut down by radio guidance command, 271 seconds after launch. The combined upper stages then cruised for 449 seconds to reach orbital altitude. Spin rockets were then fired to give the third stage a rate of rotation of 125 r.p.m. The third stage separated 720 seconds after launch, burning for 42 seconds, and went into orbit with the payload. *Tiros 2* separated from the third stage by spring mechanism 118 seconds later and went into orbit, 880 seconds after launch.

A "yo" system was employed to de-spin the third stage and to tumble it to prevent collision with the satellite after separation. The system consists of a small aluminium weight suspended on a nylon cord; with payload separation the cord begins to unwind and the force created counters the spin and causes the rocket to tumble end-over-end.

Thor-Delta booster

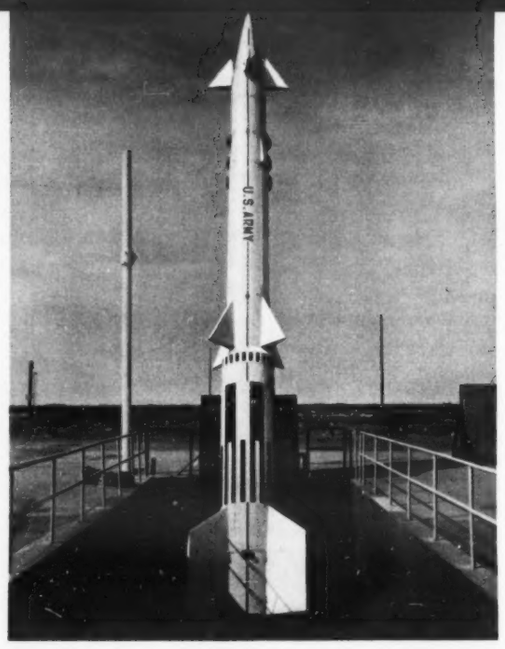
NASA used a Douglas *Thor-Delta* booster to launch its *Tiros 2* weather satellite. This rocket, a derivative of the SM-75 *Thor* IRBM, was launched for the first time on May 13th, 1960; among its successes was the placing in orbit of the *Echo* balloon satellite. Twelve *Thor-Delta* launchings are scheduled up to the beginning of 1962.

The three-stage *Thor-Delta* which launched *Tiros 2* was 92 ft long, with a maximum diameter of 8 ft and a launching weight of 111,300 lb. Its first stage, a modified *Thor*, was 60 ft long; diameter 8 ft. Weight with propellant was 105,000 lb. A Rocketdyne MB-3 liquid rocket engine of 150,000 lb thrust supplied the power. During the first few seconds an autopilot was used for guidance; next, Bell Telephone Laboratories' radio guidance system took over.

The second stage was 18 ft high, with a diameter of 3 ft. Its weight with propellant was 4,690 lb. The Aerojet-General AJ10-118 liquid engine developed a maximum thrust of 7,500 lb. It was guided during the powered phase by the Bell Telephone Laboratories' radio guidance system, and by a Douglas flight control system during the unpowered phase. Minneapolis-Honeywell, Texas Instruments and Electrosolids Corporation are sub-contractors for the latter system, which corrected deviations from the programmed trajectory with the aid of four sets of helium jets.

The U.S. Air Force has taken delivery, at Cape Canaveral, of the Azusa Mark II *missile tracking system built by the Convair (Astronautics) Division of General Dynamics Corporation. The installation, which cost about $10 million to build, will enable missile impact points to be determined on the basis of the first trajectory data, track satellite orbits and make calculations to permit space rendezvous. The system comprises a control centre and rooms for maintenance, spare parts storage and administration. A similar installation, the Convair* Azusa Mark I, *has been in service at Cape Canaveral since 1954.*

A test version of the *Nike-Zeus* anti-missile has for the first time been successfully launched from an underground silo at the White Sands missile range in New Mexico. The pictures to the right and below show the missile and its final assembly. Test launchings are being conducted by Western Electric, Douglas and Bell Telephone Laboratories under contract to the U.S.Army. Bell has awarded Goodyear Aircraft Corporation, of Akron, Ohio, a $2 million contract for the design and fabrication of the antenna mount for the discrimination radar of the *Nike-Zeus* system. Used in conjunction with a high-speed computer, the radar will be able to distinguish live warheads from decoys; it is being tested with other components of the weapons system on Kwajalein Island in the Pacific. In summer, 1961 the *Nike-Zeus* will be fired for the first time against *Nike-Hercules* missiles, and *Atlas* ICBMs will serve as targets in 1962.



The 5 ft high third stage had a diameter of 1.5 ft and weighed 528 lb with propellants. It was powered by an Allegany Ballistics Laboratory X-248 solid rocket motor delivering 3,000 lb thrust. The third stage was spin-stabilized during the powered phase.

Project Mariner

NASA is developing the *Mariner* space vehicle for the first interplanetary missions, which will be trips to Venus and Mars. Prime contractor is the California Institute of Technology Jet Propulsion Laboratory. According to information so far received, the *Mariner* will weigh 600 to 1,200 lb and will be launched by *Atlas-Agena B* or *Atlas-Centaur*. The most favourable launching date for Venus experiments is August 16th, 1962, and November 16th, 1962 for Mars experiments.

The space vehicles will have radio/inertial guidance systems, which will take them to within 100,000 miles of the planets. From this distance Venus appears nine times as large as the moon seen from the earth, and Mars five times as large. Guidance will then be taken over by an infra-red system to be developed by Barnes Engineering Co. of Stamford, Connecticut, under contract to JPL. The head of the system will scan back and forth across the surface of the planet and orient the vehicle in space with an accuracy of 0.1°.

According to Eric M. Wormser, Technical Manager at Barnes Engineering, the equipment must be highly sensitive, as the infra-red radiation of the planet Venus comes from the upper layers of its atmosphere, where the temperature is only about −54°F. Mars has surface temperatures of 45°F at the equator and −90°F at the poles. Since it is assumed that the actual trajectory of the *Mariner* at a distance of 100,000 miles from the planets will deviate from the planned trajectory by less than 35°, a scanning mechanism with counter-rotating prisms to sweep a field view 70° wide is to be built. ←→

Del Mar RADOP towed targets

Del Mar Engineering Laboratories, of Los Angeles, has developed a series of subsonic and supersonic towed target systems. Thes high-performance systems for air-to-air and surface-to-air missile training are produced in the United States and marketed by Fairey Engineering Ltd. in Great Britain, the Middle East (except Israel), South Africa and continental Europe (except West Germany, Switzerland and Scandinavia). Dornier-Werke GmbH is sales agent in the last-mentioned countries. Representative for Australia is the Fairey Aviation Company of Australasia Pty. Ltd. The firms mentioned are responsible for the installation, maintenance and repair of the targets and for the training of operational personnel.

The Del Mar RADOP towed target systems: DX-4A tow reel and DL-45AB launcher on the port wing of a Martin B-57E.

The main component of the Del Mar system is a very light, bomb-like target of plastic with radar reflectors. The radar signals are so amplified that the echo produced by the target looks like that of a four-engined bomber on the radar display. The target can be detected on the display of an airborne radar at a distance of 20 miles, and at a distance of 150 miles on that of a ground radar. The entire system can be fitted to any kind of aircraft in half an hour, the modifications required being of a minor nature.

There are two basic versions of the Del Mar RADOP (Radar/Optical) target system: subsonic and supersonic. The simplest model is the DF-4R subsonic target, which is 8 ft long and weighs only 17 lb. The DF-4RC version has an improved radar reflector. The DF-4MFC towed target has four flares to attract guided missiles with infra-red homing heads; these flares are ignited by radio signals from the attacking or towing aircraft, or from a ground station. The DF-6MFC supersonic target has all the mechanisms of the DF-4MFC plus 24 cartridges containing fluorescent powder, which are set off to enable an attacking pilot to pick up the position of a target which would otherwise be impossible to detect.

The target launchers bear the designations DL-45 (for DF-4 series targets) and DXL-6C (for DF-6 targets). They can be attached either under the wings on normal bomb racks or on special pylons. The tow reels are powered by turbines driven by the airstream. With a turbine speed of 5,000 r.p.m., 5 miles (8 km) of tow line one millimetre in diameter can be unrolled in less than 20 minutes. The reels have a capacity of up to 6.5 miles depending on diameter.

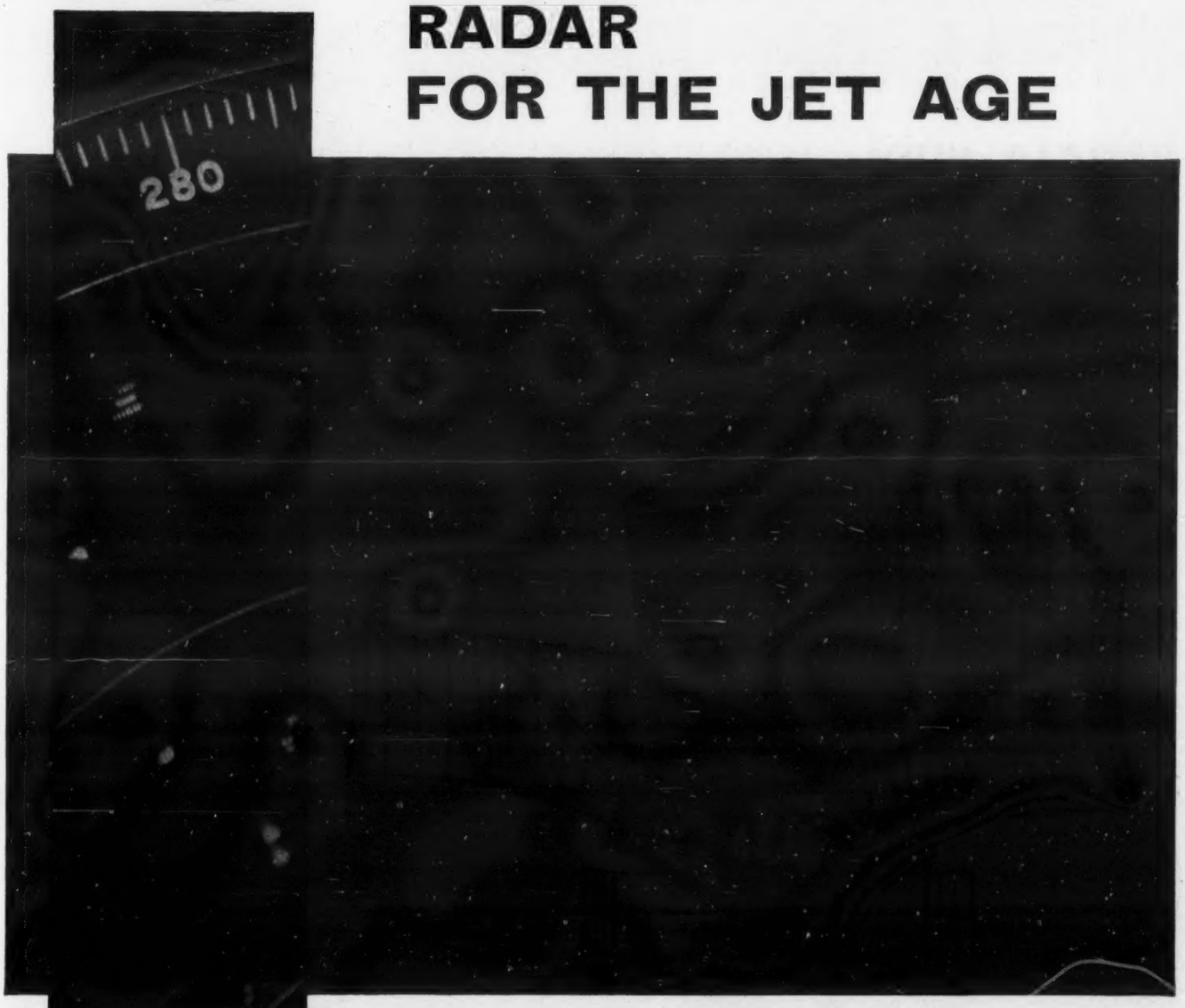
The hit indicator, known as the *Scorer*, is used for training with unguided airborne missiles and is

carried by the attacking aircraft. It records the vertical and horizontal miss distance between rocket and target on 16 mm film, together with the target range measured by ranging radar. The D-100A version for underwing installation has, in addition to the cine-camera, its own radar ranging system working on the X band; the D-100B version, which operates in conjunction with the aircraft radar, is installed inside the aircraft.

Del Mar RADOP towed target systems are already in service with the Air Forces of the United States, Canada and some NATO countries. ←→

DASR-1

THE OUTSTANDING RADAR FOR THE JET AGE



DASR-1 incorporates these outstanding 10 cm. features :—

- Absolutely constant and gap-free coverage through 360°.
- High discrimination at all ranges out to the maximum.
- A high data rate continuously maintained.
- Reduction of siting limitations due to ground reflections.
- A highly effective, fail-safe permanent echo suppression system without blind speeds.
- Sustained high performance in bad weather conditions provided by the most advanced circular polarisation system yet developed.
- A large measure of built-in ' stand-by ' facility.

Surveillance Radar with solid gap-free coverage

DECCA RADAR

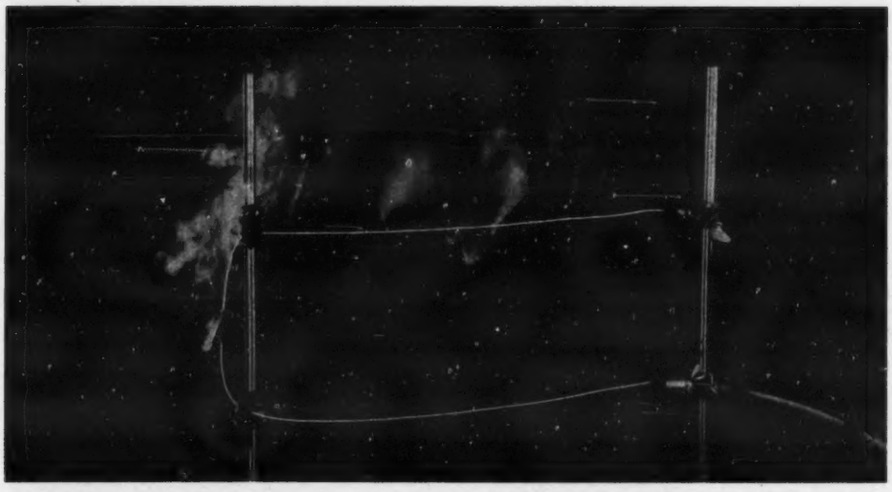
DECCA RADAR LIMITED · LONDON · ENGLAND

DR157a

AUTOLITE

THE LEADER IN AIRCRAFT WIRE!

HERE'S WHY: Autolite's Wire Research Laboratory has amassed a vast fund of answers to common problems. Moreover, Autolite's staff of Research engineers working from this knowledge with imagination and inventiveness, are constantly discovering new answers to both old and new problems. Here are just a few of the ways the Autolite Laboratory assures you of reliable, top-quality wire.



TEMPORARY OVERLOADING can lead to possible insulation damage or degradation. The ability of an insulation to withstand a sudden surge of current is a major consideration in the selection of wiring materials. Here a new silicone-rubber formulation effectively withstands a 700 per cent temporary overload which has caused a normal PVC insulation to burst into flames.

LOW TEMPERATURES cause many insulations to become hard and brittle. At the same time, the wire may also be subject to severe vibration. This cold-flexing test indicates the ability of wire and cables to withstand these aspects of a space environment.

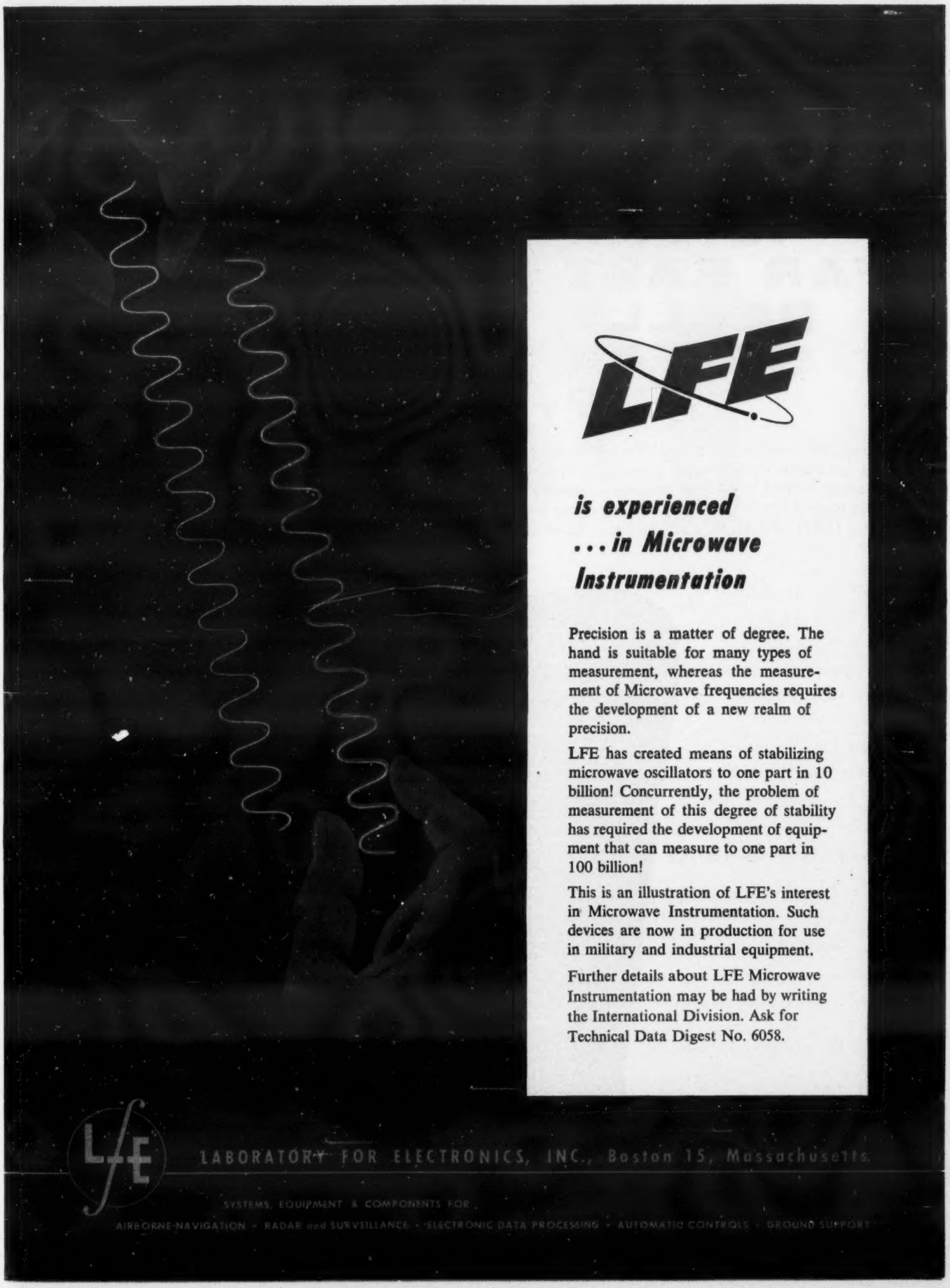
CORONA problems are compounded as air density decreases at higher altitudes. Corona can seriously disturb other electrical circuits, power losses are increased, and in extreme cases, insulation may fail completely. Testing the wire in a vacuum simulating high altitudes reveals the effectiveness of the insulation material.

If you have an aircraft wire problem, Autolite's Research Laboratory is at your command. Simply write to

THE ELECTRIC AUTOLITE COMPANY

Export Division, Chrysler Building, New York 17, N.Y., U.S.A.

AUTOLITE



LFE

is experienced
... in Microwave
Instrumentation

Precision is a matter of degree. The hand is suitable for many types of measurement, whereas the measurement of Microwave frequencies requires the development of a new realm of precision.

LFE has created means of stabilizing microwave oscillators to one part in 10 billion! Concurrently, the problem of measurement of this degree of stability has required the development of equipment that can measure to one part in 100 billion!

This is an illustration of LFE's interest in Microwave Instrumentation. Such devices are now in production for use in military and industrial equipment.

Further details about LFE Microwave Instrumentation may be had by writing the International Division. Ask for Technical Data Digest No. 6058.

L/E LABORATORY FOR ELECTRONICS, INC., Boston 15, Massachusetts

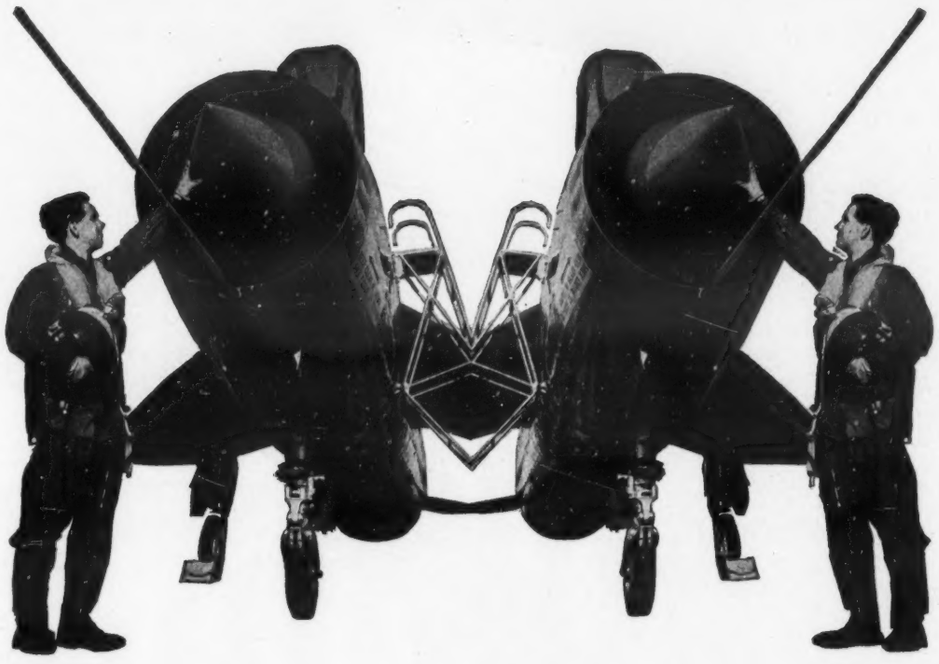
SYSTEMS, EQUIPMENT & COMPONENTS FOR
AIRBORNE NAVIGATION • RADAR and SURVEILLANCE • ELECTRONIC DATA PROCESSING • AUTOMATIC CONTROLS • GROUND SUPPORT

IS THE FAR EAST REALLY SO FAR ?

From January, 1961 onwards LUFTHANSA's modern jet airliners will link Federal Germany with two vital points in the Far East : Hong Kong and Tokyo. LUFTHANSA's Boeing 707 Jet Intercontinental, with a cruising speed of 600 m.p.h. and the superlative 1st class Senator Service, is the ideal connection between Germany and Tokyo, serving Rome, Cairo, Dhahran, Karachi, Calcutta Bangkok and Hong Kong on the way . . . and remember that LUFTHANSA jets also carry air freight. Your I.A.T.A. travel bureau or your local LUFTHANSA office will be happy to advise you.

LUFTHANSA

geissler



playing a dual rôle . . .

. . . as an interceptor and ground attacker are those aircraft equipped with AIRPASS II, the new Ferranti dual purpose radar fire-control and navigation system.

For both ground attack and interception the navigation system is fully integrated with the radar and fire-control equipment.

AIRPASS II can be used with guns, rockets, guided weapons and all types of bomb.

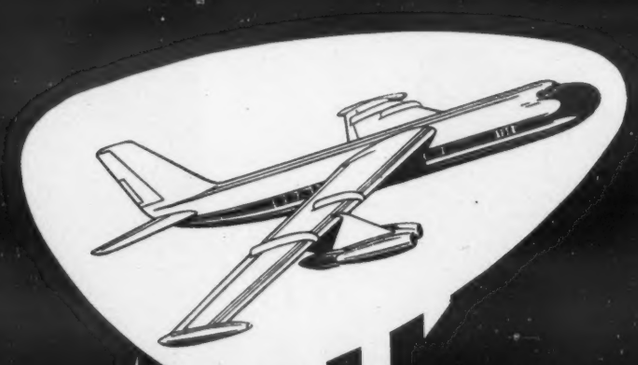
Developed from the AIRPASS system now in full production for the Royal Air Force,* AIRPASS II is specified for the export versions of the English Electric 'Lightning', the Dassault 'Mirage' III and the SAAB 'Draken'.

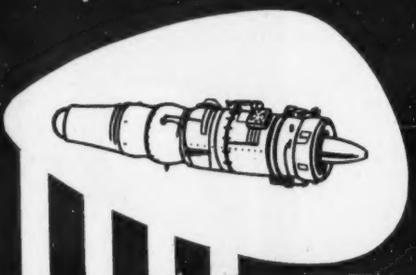
INTERCEPTION	GROUND ATTACK
● RADAR SEARCH	● GROUND MAPPING
● AUTOMATIC TARGET TRACKING	● CONTOUR MAPPING
● COMPUTER CONTROLLED APPROACH	● TERRAIN CLEARANCE
● BLIND OR VISUAL ATTACK	● BLIND OR VISUAL ATTACK

* *Ferranti are also producing a radar for the Royal Navy's Blackburn NA.39 Strike Aircraft.*

Ferranti

FERRANTI LTD., FERRY ROAD, EDINBURGH 5, SCOTLAND
Telephone: DEAn 1211





We supply:

The "152" jet airliner

The "Libelle-Laminar" and

"Libelle-Standard"

high-performance aircraft

The "Lehrmeister" two-seat trainer

for both elementary and advanced flying

Aircraft accessories and spares

TECHNOCOMMERZ G. m. b. H.
German Democratic Republic

Berlin C 2, Rosenthaler Strasse 40/41 TELEX: 011 480 TECHNOCOM Bln. Telephone: 42 52 96

LIGHT APPROACH CONTROL RADAR
TH. D. 1013

RAPIDLY SET UP, EASY TO MAINTAIN, MINIMUM SERVICING.

SIMPLE TO OPERATE (ELECTRONIC MARKING), WATERTIGHT, FOR USE IN ANY CLIMATE.

AIR TRANSPORTABLE.
TOTAL WEIGHT (including packing): 1.8 tons,
APPROXIMATE VOLUME: 424 cu.ft.

SUPPRESSION OF RAIN ECHOES, CIRCULAR POLARIZATION,

Manufactured under contract to
SERVICE TECHNIQUE DES TÉLÉCOMMUNICATIONS DE L'AIR

THOMSON CFTH HOUSTON

COMPAGNIE FRANÇAISE THOMSON-HOUSTON — GROUPE ÉLECTRONIQUE — 173 BD. HAUSSMANN — PARIS (8e) ELY: 83.70

42 52 96

The trend is towards **AIR PARTNERSHIP**

More airlines (and airports) are adopting the
Air Partner for Jet-liner starting

SAS KLM SABENA ALITALIA
TASMAN EMPIRE AIRLINES AIR-INDIA
CENTRAL AFRICAN AIRWAYS
AVENSA SOUTH AFRICAN AIRWAYS
TRANS-CANADA AIRLINES
EL-AL ISRAEL AIRLINES
CANADIAN PACIFIC AIRLINES . . .

These international airlines all use or have ordered the Atlas Copco Air Partner. Airports are also beginning to provide Air Partners as part of their ground service. Idlewild, Orly, Rome and Dusseldorf are among the first! A mobile starting unit which delivers *continuous power*, the Air Partner can be used on all jet and turbo-prop airliners with air turbine starters. A touch of the controls and it becomes an air-conditioning unit; fix a special mouthpiece to the air hose, and you have a de-icing machine. The Air Partner can be mounted on a trailer or any suitably-sized chassis—Ford, Volvo, Willys, etc.

MINIMUM MAINTENANCE

The Air Partner consists of an Atlas Copco TWIN-AIR rotary screw compressor —a design based on some ten years' testing and operating experience. Supplying a constant flow of warm, oil-free air—an essential condition for efficient starting —this compressor has few moving parts. Wear is thus practically eliminated and maintenance costs cut to a minimum—10,000 hours is the normal period between overhauls for screw compressors of this type. Maintenance on the Air Partner can be carried out by airline personnel anywhere in the world or through the Atlas Copco sales and service organisation established in ninety countries.

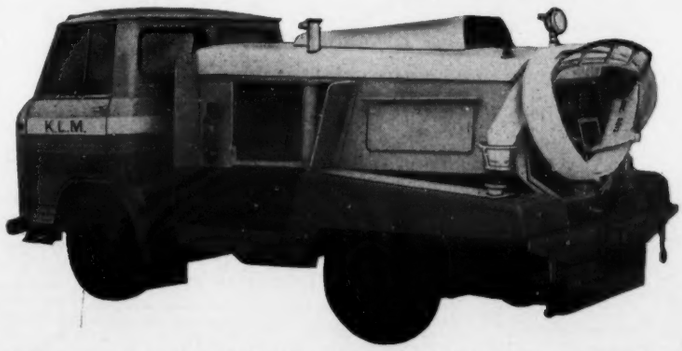
WRITE FOR THE BOOKLET

An Atlas Copco booklet giving full details of the Air Partner is readily available on request. Write for a copy to your local Atlas Copco company or agent or to the address below.

Atlas Copco

AIR PARTNER

a contribution to the jet age of air travel



Atlas Copco AB, Stockholm 1, Sweden. In the U.K.: Atlas Copco (Great Britain) Ltd. Hemel Hempstead, Herts

The French Navy Re-equips

The steadily increasing strength and importance of the French Naval Air Arm was described in detail by General L. M. Chassin in a recent issue of *Interavia.** In this article, the author drew attention to the multiplicity of aircraft types which are at present employed by the Naval Air Arm, and referred to plans which would lead to the use of exclusively French aircraft.

The reasons for this diversification of types are easily stated. At the close of the second World War, the French Navy was compelled to rely on the supply of aircraft from foreign manufacturers in order to re-equip as rapidly as possible. The French aircraft industry was still in the process of recuperation after the war, and there had been a long interruption in the design of new naval aircraft.

Today, the scene is changing rapidly. The reshaping of naval aviation is always a slow process, but the effects of long term planning carried out many years ago are now becoming apparent. Three new aircraft carriers are in the process of completion. The first of these, the *Clemenceau*, began trials in November 1959. A sister ship, the *Foch*, was launched in July, 1959 at St. Nazaire and was towed to Brest for fitting out. The third vessel, the *Jeanne d'Arc*, was designed as a helicopter carrier and commenced building in May 1960. It is planned that she will enter service in 1963.

A brief glance at the time scale involved in such a modernization programme gives some idea of the difficulties that face Naval Staffs. The order for the construction of the *Clemenceau* was signed on May 26th, 1954. Building began in November 1955, and the vessel was launched on the 21st December, 1957.

This period between the start of construction and the actual entry into service of a naval unit presents many problems for the planning staff. While the basic tasks of naval aviation can be fairly simply stated, the rapid advances in present-day technology make the selection of suitable equipment for these tasks extremely complicated.

In the case of the *Clemenceau* and the *Foch* the choice of configuration is that of a light carrier capable of carrying out a variety of missions. These can be classified as offensive, defensive and strategic transport. To fulfil these duties, accommodation is provided for 60 aircraft for strike, interception and anti-submarine warfare. This type of carrier offers the most economic answer to the requirements of the French Naval Staff. It is designed to be capable of operating in conjunction with other naval units of the NATO countries in the event of a global conflict, and it also possesses the ability to operate as a self-contained unit in any brush-fire or police action.

The first of these new naval units, the *Clemenceau*, is at present engaged in exercises and crew training in the Mediterranean. To a visitor joining her at sea perhaps the first impression is that she is smaller than expected. With a full load displacement of 30,000 tonnes she is of roughly the same size as the British carriers *Victorious* and *Hermes*. This first impression is probably due to the fact that, seen from an aircraft, the deck of a carrier under way always looks painfully inadequate.

Once on board, this impression of smallness is rapidly dispelled. An hour of steady walking along apparently interminable gangways, up and down ladders, past workshops, galleys, control rooms, crew quarters and storerooms leaves one wishing that the vessel was indeed much smaller.

For the statistically minded, the following dimensions indicate the size of the *Clemenceau*. The flight deck is 843 ft in length and 150 ft wide overall. The angled deck is 542 ft long and 96 ft wide and lies at an angle of 8 degrees to the centreline of the vessel. Two steam catapults are fitted, one on the angled deck and the second at the bow. Beneath the flight deck lies the hangar, 486 ft long, 85 ft wide and 25 ft high.

After completing a tour of the vessel, one feature becomes particularly striking. Naval forces of all nationalities are guided by service traditions, and in fact some critics have even gone to the extent of saying that they are hide-bound by them. In consequence, ship's architects have been compelled to observe many customs and usages of naval life and design the accommodation of the vessels in accordance with systems which have developed over the course of the years.

The accommodation of the *Clemenceau* has been laid out to enable the ship's company to work at the maximum efficiency and with the minimum of unproductive effort. The most expressive term to apply would be functional. This applies to the air-conditioned crew quarters, the centralized galleys and the mess decks where the ship's company eat on a cafeteria system. As the complement of an aircraft carrier consists of specialists, this domestic layout frees them from many time-wasting activities in the daily routine.

The operational design of the vessel follows the same pattern. Two aircraft lifts are installed,

The flight deck of the *Clemenceau* with representatives of the three types of aircraft embarked. An *Aquilon* is about to be launched from the forward catapult while two more are being directed by the deck party to the take-off point.

* "Retailoring the French Naval Air Arm." *Interavia* No. 10, 1960, p. 1236.

one side lift on the starboard side aft of the "island" and a forward lift on the straight deck slightly forward of the "island." This enables an uninterrupted traffic flow to be maintained. The angled deck is free of lifts, so that aircraft can be brought up on the side lift while flying is in progress and ranged for take-off on either of the two catapults. After landing, the aircraft taxi clear of the angled deck to the forward lift and can be either struck down or parked on the straight deck.

Accommodation is available for 60 aircraft, and the "air armament" of the *Clemenceau* will consist of three squadrons: one squadron equipped with *Aquilon* all-weather fighters for interception and air defence, the second squadron equipped with Breguet *Alizé* anti-submarine aircraft, and the third with Dassault *Etendard IV M* strike/interceptors. This mixed force gives the vessel a multi-mission capability and in the event of localized actions enables her to operate as a self-contained unit.

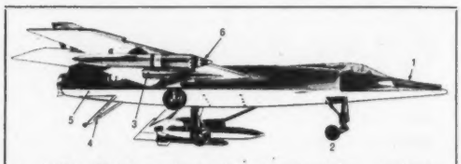
The final test of the pilot's skill. With hook extended, the aircraft is about to pick up one of the four arrester wires.

An *Etendard IV* touches down. The arrester hook has just engaged the third arrester wire while the smoke indicates that the main wheels have just contacted the deck.

An *Etendard IV* taxis up to the forward catapult. The two members of the deck party on the right are about to engage a steering bar on the nosewheel to assist the pilot in positioning the aircraft.

being carried out aboard the *Clemenceau*. The origin of this aircraft is particularly interesting as it was not originally designed for naval service. The *Etendard IV* and *VI* were prepared in response to the NATO demand for a light tactical aircraft capable of operating from unprepared terrain. This NATO demand culminated in the competition which was won by the Fiat G.91. The performance of the *Etendard* was so outstanding, however, that the French Naval Staff foresaw the possibility of using the aircraft for service in the light carriers that were under construction. Certain modifications were carried out to give the aircraft its "sea legs." These included the provision of folding wings, launching attachments and arrester hook, strengthened undercarriage and an extensible nosewheel leg to increase the incidence for take-off. The resulting navalized version displays ideal handling qualities for deck operations. The landing speed is 120–125 knots, and the aircraft's clean lines allied to the rapid response of the SNECMA *Atar 8* engine reduce the hazards of deck landing to a minimum.

The *Etendard IV M* is intended for strike or interception missions at low or medium altitudes. Its armament consists of two 30 mm cannon, and a variety of weapons can be carried externally on underwing pylons. According to the mission, these weapons may be either high explosive or



1. AIDA Radar. 2. Extensible nosewheel leg. 3. Air-to-air or air-to-ground missiles. 4. Arrester hook. 5. Detachable rear fuselage. 6. Rocket launcher.

Etendard IV M. Performance details

Span	31.49 ft
Length	47.08 ft
Sweepback	45°
Catapult take-off weight	19,400 lb
Max. deck landing weight with external stores	14,300 lb

Powerplant: SNECMA *Atar 8*, thrust 9,680 lb

Internal fuel capacity: Fuselage tanks	590 Imp. gals
Wing tanks	140 Imp. gals

In-flight refuelling facilities are fitted.

Armament

2×30 mm cannon with 250 rounds. External: 4 rocket launchers; 4×18 SNEB 68 mm rockets or 4 missiles (2 Nord 5103 and 2 *Sidewinder*) or 2×400 kg bombs or 2×225 kg bombs

Performance

Catapulting speed	130 knots
Time to 42,000 ft.	6 minutes
Max. speed sea level	630 kts/Mach 0.96
Max. speed at 35,000 ft	Mach 1.06
Max. diving speed	Mach 1.4
Deck landing approach speed	120 knots
Range at 42,000 ft	435 miles
Range at low altitude	265 miles

At present the *Aquilon* and *Alizé* squadrons are embarked, and training exercises are in progress. As the *Etendard IV M* is a newcomer to the French Naval Air Service, the first aircraft are now in process of delivery from the constructors. Orders have been placed for 50 aircraft, and a further 50 (some of which are reconnaissance versions) are provided for in the Naval estimates as a follow-on order.

Pending the formation of the *Etendard* squadrons, deck landing and launching trials are

From left to right, three stages in the take-off. With wings folded an *Alizé* awaits the order to start-up. It is then guided on to the catapult and is seen finally nearing the end of the catapult stroke.

tactical nuclear bombs, and air-to-air and air-to-ground missiles.

Conversation with both pilots and maintenance crews reveals a high appreciation of the qualities of the aircraft. The handling characteristics and manoeuvrability in flight make it an excellent fighting machine from the pilot's point of view. It is extremely stable and in consequence it forms an ideal weapons platform for the release of missiles or for cannon fire. A Dassault AIDA radar (DRAA.3D) is fitted in the nose of the fuselage in a self-contained unit. For servicing or replacement in the event of malfunction, the whole fuselage nose containing the radar unit can be detached and the faulty unit exchanged. This modular construction enables the radar technicians to carry out repairs and adjustments to the unit in the properly equipped radar workshop, rather than working in difficult and cramped conditions on the aircraft. As the operational success of a strike aircraft is largely dependent on the quality of its radar, this simplified maintenance system ensures a high degree of radar serviceability. Similarly, the engine and airframe reveal the same robust construction, so that the effectiveness of the aircraft in naval service appears assured.

When the *Etendard* squadrons are embarked, the *Clemenceau* will become a self-contained and extremely effective fighting force. The success of naval operations depends largely on information on the movement of both the enemy and one's own forces. In this respect the carrier is exceedingly well equipped. Above the "island" an array of radar antennas constantly keep watch. Two large surveillance radars are fitted, together with two heightfinders to pass information to the directing staff, who occupy a large control room within the "island." To ensure speed of command, a second and smaller control room is built on the Admiral's bridge so that the commander can see immediately the tactical situation. The information displayed in this command centre is relative to the operational employment of the aircraft, while the main control room is also concerned with the navigational assistance and guidance of the aircraft for landing. By this separation of information the command function can be carried out more quickly and with less opportunity for confusion.

In an aircraft carrier the "island" is always the nerve centre of the vessel. On board *Clemenceau* the "island" consists of three bridges. Apart from the Admiral's bridge already mentioned, there are also a navigation bridge for the watch-keeping officers and a flight deck control bridge for the command of deck operations. These three points form a closely interlinked unit from which control can be exercised with the minimum of intercommunication.

Flight deck scene. The array of radar antennas is seen above the "island." The circular radome on the right houses the landing guidance radar.

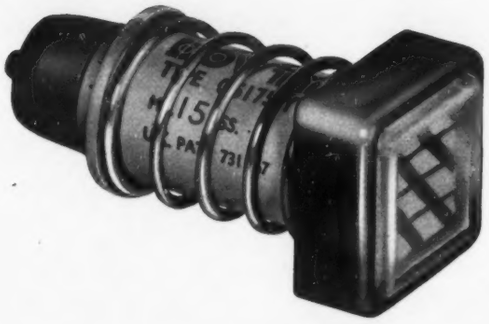
All-weather fighter. An *Aquilon* of the French Navy in flight.

*

The very size and complexity of a modern naval vessel makes its description a lengthy affair. The foregoing comments should, at least, show that French naval aviation is at last entering into its own again. The period in which the non-existance of suitable French-built aircraft necessitated the employment of a diversity of foreign-bought types is over. French shipbuilders and aircraft constructors have achieved the production of a powerful and advanced fighting unit, the most developed among the Western European Powers. It is fitting that this first evidence of the resurgence of French naval force after a period of difficulties should be named *Clemenceau*. As befits its name it is only right that the ship's crest should be a tiger's head. ←←

Electronics in Aviation and industry

What's New in Electronics?



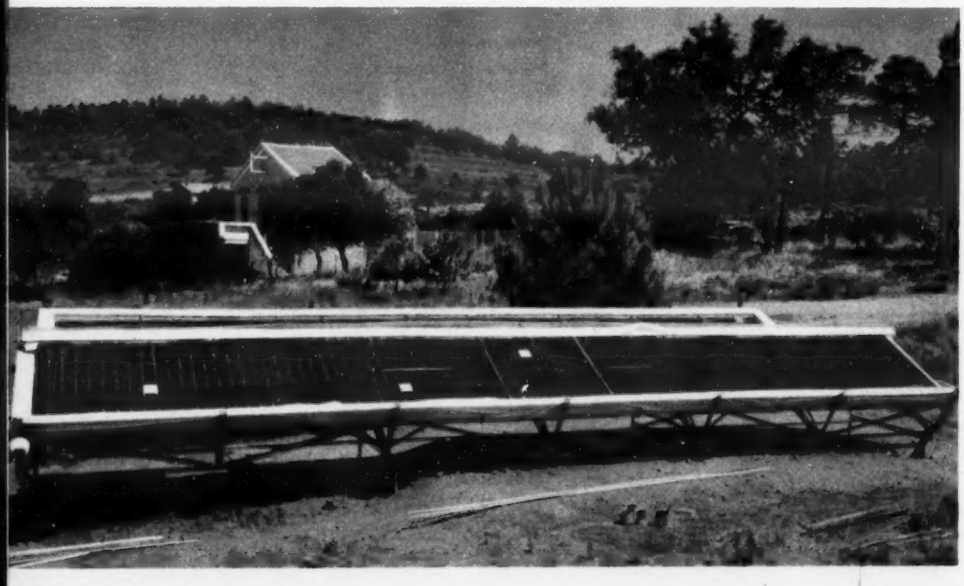
■ **Dowty Electrics Ltd., Tewkesbury, England,** has supplied 3-Position Magnetic Indicators for the main power control panel of the recently commissioned aircraft carrier, H. M. S. *Hermes*. Three display patterns are formed on prisms actuated by twin solenoids. The first pattern is shown when one coil is energized, the second when the other coil is energized and the third when the unit is de-energized. The twin-solenoid actuation thus gives immunity from filament failure.

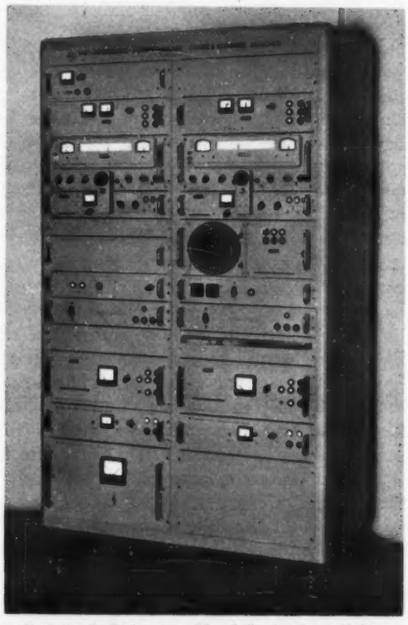
■ **CSF — Compagnie Générale de Télégraphie Sans Fil, Paris,** has been conducting a research and development programme on behalf of the BIA (Bureau d'Investissement en Afrique) in the conversion of solar energy into electrical power. This programme has also received assistance from the Service Technique des Télécommunications de l'Air. CSF has recently announced that a solar battery is now operational at Toulon and is undergoing development trials.

As the equatorial and tropical areas of the world extend over 40% of its land mass, solar energy as a power supply is extremely attractive. A further advantage is that the erection and operation of a static converter of the sun's energy is the most practical solution to the problem of establishing a power source in under-developed areas such as these.

The CSF solar battery utilizes the heat energy of the sun as distinct from the light energy, as is the case with selenium cells. The output of the installation illustrated is of the order of 10 W per square metre of collector surface. Owing to fluctuations in the sun's intensity during the day it is more practicable to say that the solar battery is capable of delivering 50 Wh per square metre daily. The total surface of the generator is 17 square metres, and in temperate latitudes this surface area can produce 100 watts of power in the midday sun.

The use of such generators offers a wide range of possibilities in conjunction with transistorized or semi-transistorized equipment, for the setting up of communications networks, for use in aviation or maritime safety, and for meteorology.





■ **Rohde & Schwarz, Munich.** In the article on the Rohde & Schwarz automatic commutated antenna visual D/F systems (*Interavia* No. 12/1960, p. 1510), *fig. 2* was not, as stated, the main station for the NP4 D/F system, but a duplicated UHF radio tranmitter. The correct picture accompanies this text.

■ **Decca Radar Ltd., London,** has developed the 21 in. display console, illustrated here, for use in Operations Rooms and for positions where it is desirable for more than one person to view the displayed radar picture, so that liaison is made easy and direct. The face of the tube is horizontally mounted and positioned at the centre of a table-top so that at least four people can be grouped round the display. The table-top can carry controls for special interscan facilities such as bearing and range measuring lines.

■ **Avien, Inc., Woodside, N. Y.,** has announced the development of a lightweight, low cost, air transportable dual-polarized VHF tracking and telemetry antenna which has been designed for use in missile tracking applications. The new antenna operates in the frequency range of 215—260 Mc/s and measures 8 ft square by 6 ft deep when in operation. It is built on a modular concept, and it is possible to erect antenna systems of varying sizes and capabilities by changing or re-arranging the standardized elements.

■ **ACF Industries, Inc., Riverdale, Md.,** has announced the development of a flight simulator to assist in the training of pilots in the use of NASARR (North American Search and Ranging Radar). The simulator will produce displays (on a scope viewed by the pilot) for ground mapping, contour mapping and terrain avoidance, by means of a television camera and a low-power light source in conjunction with a three-dimensional terrain map. The pilot and crew can be taught radar interpretation under actual flight conditions without the problems actually encountered in flight. Terrain models, which represent an actual land area, can be constructed to copy any geographic features such as rivers and mountains.

■ **Cossor Radar — Electronics Ltd., Harlow, England,** has been engaged for several years in the development of secondary radar ground and airborne equipment. The recent announcement that an agreement has been reached between officials of the Federal Aviation Agency and the Ministry of Aviation as to compatible characteristics of secondary surveillance radar and sidelobe suppression has considerable bearing on the work of the company.

A two-pulse system of sidelobe suppression was agreed upon at an ICAO conference in 1957. In the summer of 1959 the Federal Aviation Agency in the United States proposed a three-pulse system, in which one of the interrogator pulses precedes the control pulse and is used to discriminate against sidelobe interrogations.

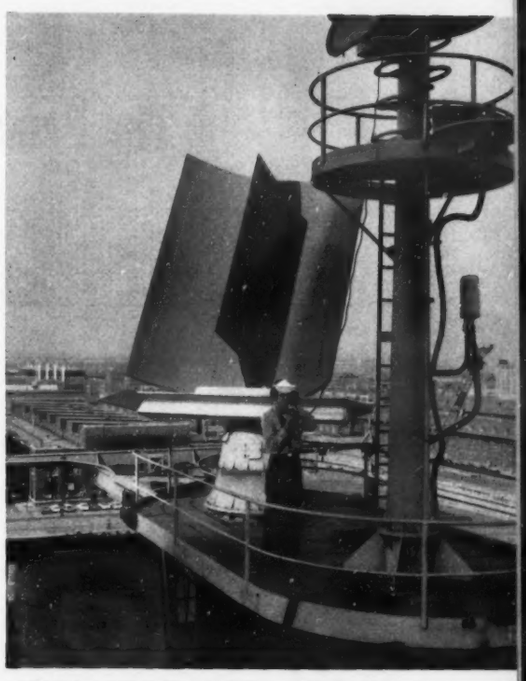
Both the Cossor airborne transponder and ground interrogator are designed to work with the two-pulse system already agreed upon, but can be modified to work with the three-pulse system if required.

A secondary surveillance radar system is capable of providing air traffic controllers with far more information than is possible with primary radar alone. A choice of modes of interrogation, in combination with coding of transponder replies, provides an efficient system for the transmission of information. This reduces the load on aircrew and ground personnel by eliminating a substantial amount of R/T communications. As secondary radar does not rely on the reflection of energy by the aircraft, but on the triggering of the airborne transponder, it has greater range potential at moderate powers than primary radar.

The problem of sidelobe suppression has been the great delaying factor in the establishment of international agreement on secondary radar characteristics. A transponder sensitive enough to be triggered at extreme ranges would also be triggered at medium ranges by sidelobes of the interrogator radiation pattern. The replies to such interrogations would be received by the same sidelobes and would be displayed at the correct range but on incorrect bearings. As a result, large arcs could be produced on the PPI display, and in the worst cases these could be complete circles. Other undesirable effects arising from sidelobe triggering are heavy interference on the displays of other ground radars, and the tendency for transponders to be captured by local interrogators, thus denying service to more distant stations. The difficulty is overcome by the use of multiple-pulse interrogations radiated by a combination of directional and omni-directional aerials, together with suitable discriminating circuits in the transponders. This prevents the transponder replying to interrogations except when the aircraft is in the narrow main beam of the interrogator aerial.

The Anglo-U.S. agreement on secondary radar techniques will accelerate the introduction of this equipment into general service. At present, secondary radar transponders are mandatory equipment for turbojet airliners in the USA, and it is widely recognized that before long they will be essential on all aircraft flying on or near airways. When this happens it is likely that secondary radar will become the principal aid to air traffic control.

■ **Remington Rand Univac Division, New York N. Y.** has developed a thin-film computer memory with the fastest access time of any memory developed to date. It is constructed of a thin film of ferro-magnetic material (a few millionths of an inch thick) made by depositing vapours of iron, nickel, cobalt, or other ferromagnetic metals or their alloys, on a suitable base such as a thin glass plate. The film has very unusual properties when deposition is made under controlled conditions. If a magnetic field is applied parallel to the surface of the base during deposition, the thin film then becomes easier to magnetize in the direction of the field in which it was applied than it is at right angles to that direction. This property permits the magnetic state of such a film to be switched in as little as 1 thousand millionth of a second. In a computer memory, this means that information can be stored in and retrieved from the memory with a speed directly related to the speed required for switching the magnetic state of the memory. In addition to the high speed switching time, the thin film has the added advantage of having a catalogue type memory. This means that its store of information can be interrogated and read out millions of times without destruction. It also requires less electric power for energization than do other memories. This new memory store is used in the Remington Rand Univac 1107 computer and enables a cycle time (the time required to read and write information) of only 0.6 microseconds to be achieved as compared with the cycle time for a ferrite core memory of 1.5 microseconds.



■ **Hughes Aircraft Company, Culver City, Calif.,** has announced that missile-armed cruisers and destroyers of the U.S. fleet have been equipped with *Frescan* three-dimensional radar. This is a powerful, lightweight radar which uses only one antenna and which simultaneously provides the three essential items of target information—range, bearing and altitude. The radar antenna is illustrated on the masthead of the missile cruiser USS *Galveston*. A particular feature of the installation is that the antenna is electronically stabilized, thereby obviating the masthead weight of heavy mechanical gyro-stabilization equipment. Range and height information is obtained by electronic scanning in a vertical plane, while rapid rotation of the antenna supplies target bearing. Roll and pitch signals from the ship's main gyro are supplied to a computer which automatically modifies the elevation beam scanning programme and presents the true position of the targets on the radar scopes. The second illustration shows the two scopes of the *Frescan* in the combat information centre of the USS *Galveston*. Target bearing is shown on the PPI at the left, while range and height information is displayed on the scope at the right.

The Remote Transmission of Radar Information

By Heinz Hart, Telefunken, Ulm

Nowadays radar is indispensable both for air traffic control and for a variety of other civil and military applications. To perform these tasks, several categories of radars with different characteristics have been developed: airfield surface movement radars, harbour radars, airport surveillance radars, and medium and long-range radars. Secondary and heightfinding radar systems are also entering service in increasing numbers.

In order to achieve the best possible coverage the antennas, together with their transmitters and receivers, must be sited at the locations most favourable for propagation, while the radar data are evaluated in operations rooms which are often at a considerable distance from the antennas. The information must therefore be sent by cable or radio link from the radar to the place where it is to be evaluated. Future airspace surveillance and air traffic control systems will be largely automatic but will continue to make use of radar information; the remote transmission of radar images or data is therefore assuming increasing importance.

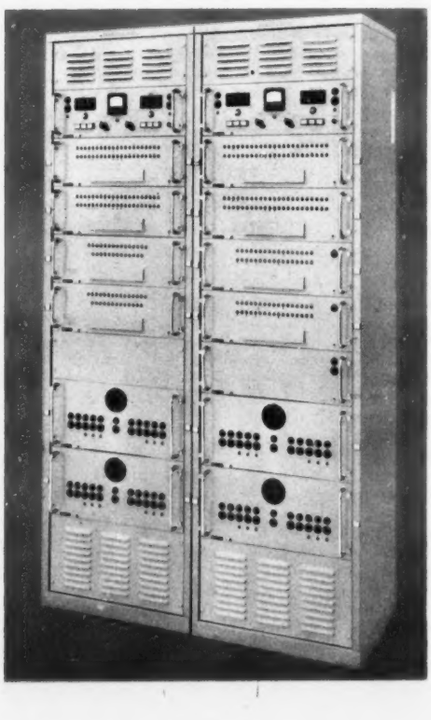
Wide-band procedures

Disregarding television scanning of the radar image, the most obvious method of transmitting radar pictures is *video frequency cable transmission.* This is used, for instance, for airport surveillance radars, whose antennas, together with their transmitters and receiver, are normally located at the edge of the airport, with the displays in the control room. In video frequency cable transmission, which is generally considered suitable for distances of up to 2 miles, the radar pulses are transmitted scan by scan in their original form, to correspond with the radial structure of the PPI picture, the frequency bandwidth remaining unchanged. If several types of video signal must be available at once in the control room (for example, MTI video in addition to normal video), each requires its own HF cable. The synchronization pulse can be sent by the same cable as one of the video signals, while normal signal transmission is sufficient for the transmission of azimuth data from the antenna.

The bandwidth necessary for the transmission of video frequency pulses depends primarily on the pulse length, which in its turn determines the radial discrimination of the radar equipment concerned. This is shown by the following actual example; in airport surveillance radars the pulse length is normally one microsecond. This corresponds in theory to a radial discrimination of 165 yd (azimuth discrimination depends on the sharpness of the radar beam). In installations of this kind, bandwidths of the order of 2 Mc/s are normal for the transmission of video frequency pulses. Here it should be stressed that the receiver IF bandwidth must be large enough to remain unaffected by frequency fluctuations in the oscillator. Often, a greater video amplifier bandwidth is chosen than would be necessary according to theoretical calculations, to avoid pulse distortion and hence a deterioriation in the quality of range discrimination. Radar targets lying close together on the screen appear as separate features on the picture only if the pulses are sharp enough. Pulse rise and fall times must therefore be taken into account in the remote transmission of radar images.

If radar images are to be transmitted over a longer distance than 2 miles, the video frequency method becomes impracticable for technical and economic reasons, for the increasing cable attenuation would require the use of amplifiers or expensive special cables. To bridge longer distances, therefore, *transmission by cable on a carrier frequency* is preferred. With this method, the carrier frequency (say 21 Mc/s) is modulated by a video signal, thus creating an upper and a lower sideband in addition to the carrier. This procedure has the advantage that, while the absolute bandwidth remains unchanged, the bandwidth relative to the carrier decreases. This lessens both attenuation and differences in travel time. If a number of video signals are to be transmitted, the carrier frequency technique allows the cable to be used several times over by a frequency spacing procedure, in other words a carrier frequency band is formed, over whose frequency spectrum the individual video signals are distributed.

Fig. 1: Telefunken local oscillator for wide-band radar image transmission.



The double sideband method is, however, of little use for short-range radar systems, as it would require too wide a frequency band. In such cases use is made of the single sideband method, or the vestigial sideband method used in television transmissions (here a portion of the second sideband is also transmitted to reduce distortion at low frequency).

Telefunken is at present setting up a carrier frequency transmission system for the harbour radar at Hamburg. Here the images furnished by a number of unmanned radar stations must be sent to an operations room for evaluation. A cable transmission device has been preferred to a directional radio link, as the necessary freedom of propagation cannot be ensured in a harbour owing to the presence of cranes, ships and other obstructions.

Video and carrier frequency signals can also be transmitted via *radio link,* and Telefunken is supplying an installation of this kind at Hanover. The new medium-range radar which will control traffic in the airspace over North Germany has been set up on a hill near Hanover, but the displays are in the airport control room. The installation comprises the radio link with the appropriate local oscillators (cf. *fig. 1*) for two radar pictures and the antenna follower. Telefunken has supplied a further local oscillator for radar image transmission from the Odenwald to Frankfurt am Main Airport control room.

The frequency spectrum of the channel transmitted in both cases contains at its lower end the normal video (from 0 to 1 Mc/s) and the two sidebands of the MTI video (from 2 to 4 Mc/s); when the latter signal is modulated, the two sidebands appear on a 3 Mc/s auxiliary carrier. Above this lie three further auxiliary carriers, spaced at distances of 150 kc/s; these contain antenna azimuth information (cf. *fig. 2*). As medium-range radars require less range discrimination than those used to control the immediate vicinity of an airport, a pulse length of 2 μs with a bandwidth of only 1 Mc/s is adequate for the case under consideration.

Highly comprehensive radar image transmission installations are required for special military warning systems. Several transmission systems are installed at each radar position; in addition to the long-range plan position radar, these include the IFF (secondary) radar and several height-finders. Here, too, data are evaluated in a remote

control room, which can be up to a few hundred miles away. It is essential, if an effective, integrated airspace surveillance system is to be achieved, to coordinate in control centres the information received from a number of radar sites.

Military systems require the transmission of a considerably larger volume of information than do civil installations; such information includes normal video, logarithmic video, integrated video and MTI video from plan position radars, normal video signals from the individual height-finding radars, and coded and decoded IFF signals from secondary radars. As the range discrimination requirements for long-range military airspace surveillance radars are less stringent than those for medium-range radars, transmitter pulse lengths of 2.5 to 5 μs are normal. On the one hand, the longer pulse length increases the detection range; on the other, it reduces bandwidth requirements for radar image transmission. Nevertheless, total bandwidths of the order of 10 Mc/s are required to accommodate the individual frequency-spaced video channels on a single carrier frequency channel. A bandwidth of this order is normally transmitted on the centimetric range by modern radio link systems (cf. *fig. 3*). To the radar signals themselves must be added remote control and remote monitoring signals, i.e., angle of azimuth signals, angle of tilt data, switch commands and acknowledgments. These must also be passed via the radio link, but their bandwidth requirement is negligible by comparison with that of the video signals.

All such wide-band procedures ensure the fulfilment of the requirements for the remote transmission of radar images, namely, that the image should not differ appreciably from the original, that the various types of radar signals (such as normal and MTI video) must overlap exactly, and that unlimited range scale changes and off-centring must be possible at the slave displays.

Narrow-band procedures

For the transmission of radar pictures over very long distances it is often necessary, for technical or economic reasons, to limit the frequency range required. Endeavours in this direction have been aided by the modern theory of information, which has become increasingly prominent in recent years. This can be briefly summed up as follows.

In principle, it is possible to restrict the frequency band required for the transmission of radar pictures by *slowing down transmission*. Taking as a basis the fact that a maximum of about 500,000 blips can be presented on a cathode ray tube, and that the picture does not have to be presented more than once per antenna rotation (as no new information appears more often than this), a bandwidth no wider than about 80 kc/s is necessary. For short-range radar installations, such as a harbour radar with a pulse length of 0.08 μs, the saving in bandwidth is considerable. While a minimum video bandwidth of 6.25 Mc/s is necessary for wide-band transmission, with decelerated transmission about one eighthieth of this, i.e., 80 kc/s, will do.

Medium- and long-range radars operate with considerably longer scanning pulses than short-range radars, and even without compression need video frequency bandwidths between only 100 kc/s and 1 Mc/s, so that little bandwidth is saved. As, moreover, independent scale changing and off-centring facilities must be available at the slave

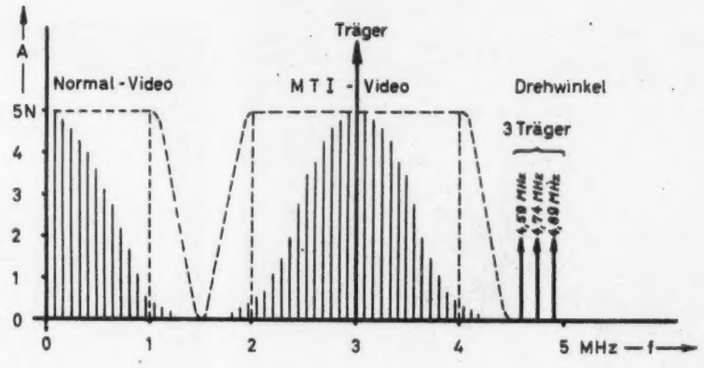


Fig. 2: Carrier frequency channel with two wide-band video signals and three antenna follower signals: reference phase, coarse (1 : 1) measuring phase and fine (10 : 1) measuring phase.

displays, the number of video components transmitted increases, together with the necessary bandwidth, and this means that the saving factor is again reduced.

If the necessary saving in bandwidth cannot always be achieved with decelerated transmission, there is another method which gives more successful results. The video signal contains more information over its full bandwidth than is necessary or can be evaluated. This is known as *redundancy*, which appears in the following form in radar equipment.

1 – *Dead time* between the end of one scan and the beginning of the next. This is particularly long in the case of short-range radar installations, as the actual scanning time takes up only one third of the pulse period, while the remaining two thirds are dead time. In medium- and long-range installations the dead time is, however, considerably shorter.

2 – *Multiple scanning* of the target: In the time during which the beam is scanning the target, a number of pulses (five to twenty) strike the target.

3 – *Scan overlapping* near the centre of the PPI display.

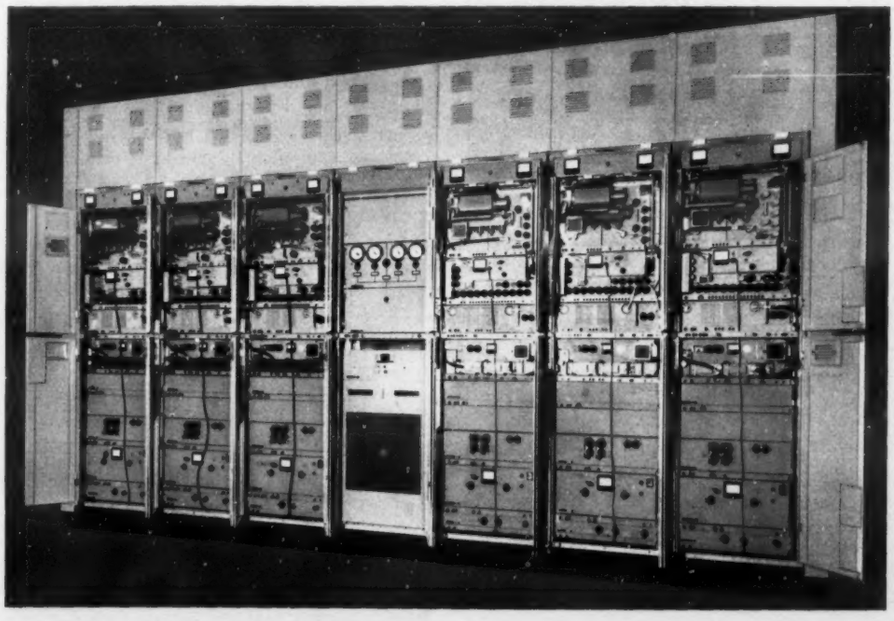
4 – *Low information content:* Only a fraction of the maximum number of blips which can be displayed on the screen are actual echoes, of which few are of any value for information purposes (e.g. aircraft blips for air traffic control radar).

As the useful information content of the radar image often requires transmission bandwidths of only about 100 c/s, the transmission channels can be put to the most economical use by eliminating as far as possible all sources of redundancy, and the greatly increased requirements for recording radar images on magnetic tapes (cf. *fig. 4*) can be met.

The echoes which occur during the dead time do not appear on the radar screen and do not therefore need to be transmitted. The picture is fed scan by scan into a *line store*, slowly rescanned (using the dead time between successive scans) and at once extinguished. The short pulses are lengthened during the slow scanning process and can be transmitted on a narrower bandwidth. For under a basic law of communications techniques, an inverse ratio exists between bandwidth and transmission time.

For the presentation of several scans at once, a number of scans are added together in the line store and read off together. Such a synthetic process enables the reading time to be further extended and additional bandwidth compression to be achieved. If too many scans are presented together, however, azimuth errors will occur and spokes will form.

Fig. 3: Modulator and transmitter/receiver of a microwave radio link in the 4 Gc/s range.



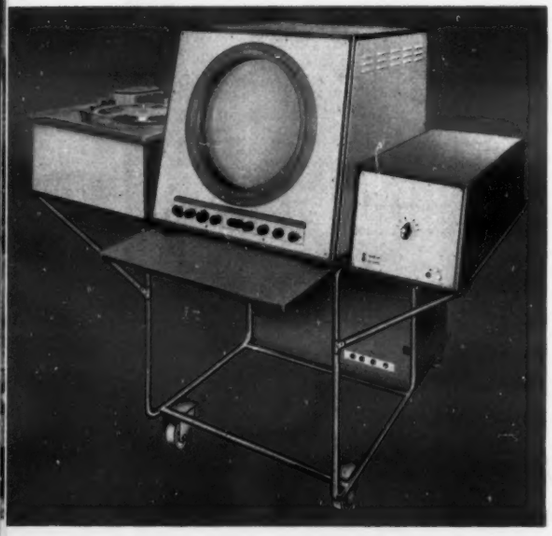
Telefunken has developed a storage system of this kind for the transmission of harbour radar pictures, which enables the original transmission bandwidth to be compressed from 6 Mc/s down to 400 kc/s without loss of information. The quality of the picture as regards range discrimination and the distinction between strongly and faintly reflecting echoes remains unimpaired; indeed, the more effective integration in the store even improves resolution between targets lying close together. The Telefunken system requires special displays with slower time deflection, or expanders to enable normal displays to be used.

The formation of spokes is particularly undesirable in harbour radar, as targets approaching each other, such as ships carrying out overtaking or mooring manoeuvres, must appear as separate echoes for as long as possible. For airspace surveillance and air traffic control radars, on the other hand, reduced azimuth discrimination and even reduced range discrimination are acceptable. The latter can, indeed, be so far reduced that square echoes appear in the middle of the range scale, for spacings between aircraft in the air are relatively great.

As the line stores are designed to accept a large number of echoes (in the Telefunken bandwidth compression system just mentioned, the number of echoes which can be stored by the tube is Π times larger with circular deflection than with linear deflection), the range discrimination should be reduced by integration. By a synthesis of several scans and by extending the range elements, a bandwidth compression can be achieved which allows the transmission of radar pictures over telephone channels, though with poorer quality and without the facility for changing the scale at the remote slave display.

In the centre of the normal polar coordinate radar presentation, part of the information contained in the video signal is lost because of the overlapping scans. As this part of the information cannot be used in any case, it does not have to be transmitted, so that a further saving in bandwidth is obtained. This redundancy can be eliminated with the aid of *memory stores*, which are available in various versions. A well-known example of these are the scan conversion storage tubes developed by a French firm, where the write and read systems are separate. The tubes store the complete picture, which is then rescanned by a 625-line television system. If the picture is scanned no more often than necessary, in other words no more often than once for each rotation of the antenna, then the transmission bandwidth can be compressed to about 12 kc/s to correspond with the lengthened time base (from $^1/_{25}$ second for normal television to the duration of an antenna rotation, e.g., about 15 seconds). The signal thus obtained contains the radar image in the form of Cartesian coordinates without scan overlapping. As the same time, the redundancy occuring in dead time and multiple scanning is exploited. Separate transmission of antenna azimuth information is eliminated, as it is already contained in the image structure.

Fig. 4: Telefunken radar simulator. The equipment works on the line storage principle and is also suitable for recording radar pictures on magnetic tape. It comprises display, magnetic tape recorder and video mapping equipment.



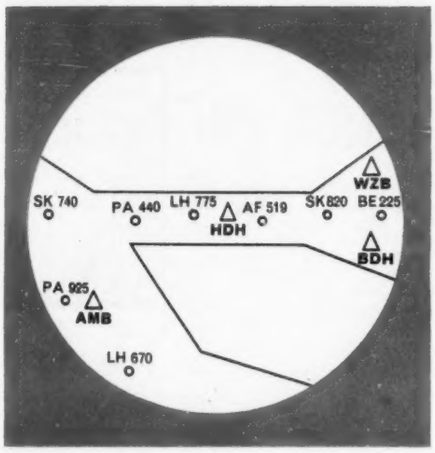


Fig. 5: Synthetic radar picture for air traffic control. Aircraft are marked with circles and flight numbers, reporting points by large triangles with designations of locality.

A special display with slow time base or an expander for use with normal displays, is used to present the remotely transmitted radar picture. Expanders contain a scan converter, from whose storage surface the radar image is scanned at the normal television scanning speed. These devices also permit changes in scale and off-centring. As, however, the number of blips which can be stored in any system is limited—between 500 and 1,000 according to type—discrimination may in some cases be impaired. There are also certain limitations as regards the ability to distinguish signal brightness.

The use of scan converters also has its advantages at locally controlled radar stations, as the radar image can be observed in daylight. In many cases such a system may be adequate for general air situation presentation. Scan conversion tubes can also be used for wide-band radar transmissions. Special 945-line converters for daylight observation have recently been offered in the USA. They are reportedly graded for five degrees of signal brightness, and the storage time can be adjusted to enable flight paths to be observed.

Synthetic radar picture

The use of the last source of redundancy, namely the low genuine information content of a radar image, leads us to the *digital radar*. Here each target of interest (e.g. an aircraft) is designated by a binary code which can be transmitted by normal telephone lines.

As air traffic control is showing an increasing requirement for systems with automatic evaluation of radar information and data coding, systems by which the radar information can be fed directly to the air traffic control computer in digital form, the exploitation of this redundancy is in line with general development trends. In principle, the conversion of the information content of a radar image is possible by two different methods:

- obtaining analogue, Cartesian coordinates (X/Y values) by means of tracking systems, with subsequent analogue-digital conversion;
- the direct digitalization of radar echoes into polar coordinates (rho-theta values) with subsequent conversion to X/Y coordinates.

The tracking procedure, which is already in operation in many quarters today, is particularly useful for the evaluation of radar images in control centres, while the second method is eminently suitable for operation directly at the radar output.

The simplest kind of tracking operation is carried out manually. The target is tracked on the screen by means of an electronically superimposed symbol, which is moved with the aid of a control column whose deflections generate electrical voltages analogous to the X/Y coordinates of the target. The voltages are fed to an analogue-digital converter and transmitted in the form of digital data. A number of targets can, of course, be followed simultaneously with the control column, if the data are in the meantime kept in a store.

The next step is semi-automatic follow, in which manual corrections are necessary only where a target alters course and speed. With full automatic follow, these alterations are fed automatically to the equipment.

An alternative to the tracking method is to obtain coordinates by direct digitalization from the video signal. This leads to the digital radar, at present under development. The transmitted digital data are fed into the computer and presented on the radar screen. Instead of the "raw" radar image there appears a synthetic, filtered image containing only the symbols allocated to each target, with their alpha-numeric data, but without noise background (cf. *fig. 5*).

In future airspace surveillance and air traffic control systems, the automatic evaluation of coded radar information will assume increasing importance. Radar *image* transmission will undoubtedly become quite distinct from radar *data* transmission, and it will be possible to use normal telephone channels instead of today's costly remote transmission systems. Original radar images will then be used only to give a general idea of air situations, for meteorological information and for the control of installations for which very narrow band transmission is adequate. ←→

What's in the Air?

Lulu, *the U.S. Navy's atomic depth bomb, shown in the bomb bay of a Grumman S2F* Tracker *turning over the Atlantic near Long Island, New York.* Lulu *is designed for fast, accurate anti-submarine strikes by nearly all types of Navy aircraft. Prime contractor is General Mills/Naval Ordnance Lab. The S2F also carries four conventional acoustic-homing torpedoes and two HVAR air-to-surface weapons.*

AIR TRANSPORTATION

IATA Director-General Sir William Hildred forecasts a new record total of 118 million passengers for the world's airlines during 1961. This would be a healthy increase over the 98 million passengers who flew on IATA airline services during 1959 (and on the 108 million reported by ICAO for 1960). Revenue passenger kilometres should reach 125,000 million in 1961 against 97,000 million in 1959, and cargo traffic is expected to increase from 1,920 million ton-kilometres in 1959 to a new high of 2,540 million.

Sir William said that the surge of air traffic should continue under pressure of a growing public need for international air transport, particularly to and within rapidly developing areas such as Africa and South America.

IATA's London Clearing House settled $1,127 million (£401 m.) in airline business during the first nine months of 1960, an estimated 32 percent increase on the 1959 nine months' figure of $752 million (£268 m.). Dollar and sterling settlements eliminated cash payment in 89.5 percent of all transactions cleared, and in 26 cases exceeded 99 percent.

Inter-clearances between London and the Airline Clearing House Inc. in the USA totalled $69 million for the first nine months of 1960 against $28 million in 1959. The offset ratio averaged 93 percent.

Cunard Eagle Airways (Bermuda) Ltd. has become an active member of IATA. Linea Aeropostal Venezolana (LAV) has closed down international operations and has ceased to be a member. IATA membership continues at 89 carriers.

The four Air Union carriers (Air France, Alitalia, Lufthansa and Sabena) have been continuing their discussions in Paris, and have reached an "agreement in principle." No details have been released, and the agreement will now reportedly be submitted to the Governments concerned for approval. The Sabena management feels that recent Air Union sessions have been most disappointing. The Belgian flag carrier believes that unless Air Union sees the light of day in the first quarter of this year, the whole project will have to be abandoned.

Air Force General Felice Santini has succeeded General Renato Abbriata as Italy's Director-General of Civil Aviation under the Defence Ministry (Air).

The Austrian delegation to the ICAO European-Mediterranean Regional Meeting in Paris (Jan. 3rd-24th) proposed the adoption of a new 185-mile direct air route between Vienna and Venice. This would lie across Yugoslavia and the northern Adriatic, and would replace the present 450-mile dogleg route via Munich. A new navigation beacon would be required at Ilirska Bistrica (east of Trieste) and would permit traffic to be routed via Venice to Rome. This question has already been dealt with in Austrian-Italian discussions last June, and agreement is required from the Yugoslav delegation and from IATA.

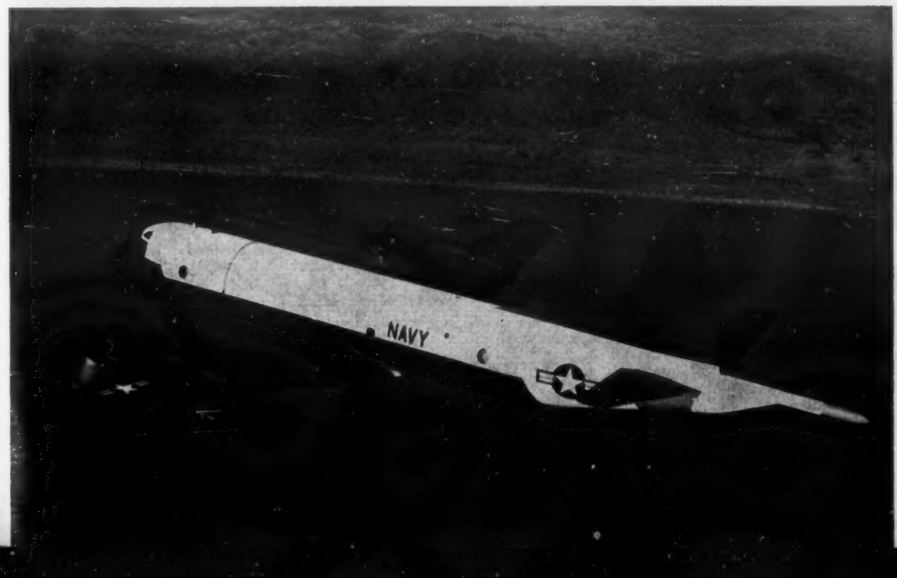
Giuseppe Luraghi, formerly Chairman of the Pirelli Group, has succeeded Balduccio Bardocci as Chairman of the Alfa Romeo company.

KLM Royal Dutch Airlines has ordered another Douglas DC-8 series 50 jet transport to bring the fleet strength up to 13 DC-8s. KLM already has seven DC-8 series 30 in service, and is scheduled to get five series 50s in 1961.

SAS Scandinavian Airlines System is training United Air Lines' *Caravelle* crews. The first four UAL pilots were due in Stockholm on January 21st, and will be followed by a second party of 33 in March. The UAL pilots will be checked out by U.S. Federal Aviation Agency officials in Stockholm. UAL has ordered 20 *Caravelles* (VI Rs).

Hugh Buckingham, Managing Director, de Havilland Engine Company, and Domenico Agusta, President and General Manager of the Italian Agusta company. Agusta has given de Havilland a £1 million order for Gnome turbine engines to power the Agusta Bell 204B helicopter.

New wide-vision cockpit windows and bullet-shaped tail extension are distinguishing characteristics for Lockheed's Y/P3V-1 ASW aircraft. This operational prototype, under flight evaluation for almost a year, is the forerunner of P3V-1s ordered under $127 million U.S. Navy contracts. The plastic tail houses the MAD (Magnetic Anomaly Detector) unit employed to determine the presence of metallic objects beneath the ocean surface. Fleet units will be armed with rockets, torpedoes and depth charges. First production P3V-1 is scheduled to fly this March.



British United Airways has applied to the Air Transport Licencing Board for permits to operate a number of new international air routes to points in Europe and Africa. This is probably a test application by the British independent in an attempt to break BEA/BOAC monopolies. Initial services would be flown with *Britannias* and *Viscounts* pending the acquisition of jet aircraft. BUA is also currently studying the purchase of up to six jet aircraft and is reportedly studying the Vickers VC.10.

San Francisco-Oakland Helicopter Airlines Inc., a new corporation, will inaugurate scheduled passenger service with Sikorsky S-62 amphibious helicopters on April 1st. The company has signed a lease-purchase agreement with Sikorsky Aircraft for two S-62s for delivery in March and April, with an option on a third for delivery in three to six months' time. A

Lieutenant Henry L. Monroe (left) and Commander Leroy A. Heath, USN, recently flew the North American A3J Vigilante *to a new record altitude of 91,450 ft (approximately 17 miles) over Edwards AFB. This tops the previously recognized record of 67,096 ft set in 1959 by a Russian twin-jet RV monoplane.*

twin-turbine 28-passenger S-61L will be procured when traffic load factors have been built up. President M. F. Bagan said that initial schedules called for about 70 flights a day serving San Francisco International Airport, Metropolitan Oakland International Airport, downtown Oakland, downtown San Francisco, Berkeley and Palo Alto. Additional cities and communities within a 100-mile radius will be added to the network later.

Air-India International will purchase two more Boeing 707 jet aircraft for delivery by March 1962, bringing the carrier's total jet fleet up to six aircraft. Delivery of the carrier's fourth Boeing 707 of the initial order is due in the spring of this year. By 1962, the carrier plans daily 707 service between London and New York, two flights a week to Tokyo, two to Nairobi and one each to Moscow and Sydney.

Allegheny Airlines has filed application with CAB for a permit to operate scheduled helicopter service in the Washington-Baltimore area. The carrier wants to operate helicopter services between downtown Washington, Washington National, Baltimore Friendship and Dulles International Airports. Allegheny currently serves twelve eastern states with almost 100 flights a day.

INDUSTRY

Sikorsky Aircraft Division of United Aircraft Corp. has received a $34.2 million U.S. Navy contract for production of the twin-turbine HSS-2 (S-61) all-weather ASW helicopter. The HSS-2 is now in the final phase of its fleet trials.

The twin-turboprop Antonov An-24 will replace piston-engine aircraft on Aeroflot domestic and feeder routes this year. Powerplant is two 2,000 h.p. Ivchenko engines each driving a four-blade variable pitch airscrew. Layout is for 32-42 passengers. Average cruising speed 270 kts. Range 430-650 n.m.

A recent photograph of the Antonov An-10 which entered domestic service with Aeroflot in 1959. Powerplant is four 4,015 h.p. Ivchenko AI-20 turboprops.

Sperry Utah Engineering Laboratory has received a $16,855,000 U.S. Army letter contract for the production of operational *Sergeant* tactical surface-to-surface missile and ground equipment. Previous *Sergeant* funding has been for equipment for R & D. The solid-fuel *Sergeant* weapon is being prepared as a successor to the *Corporal* missile currently operational with the Army.

West Germany and Britain have agreed on joint development of a single-seat combat aircraft based on the Hawker P.1127, eventually to replace the Fiat G.91. Other NATO nations will be invited to participate, and this move may be aimed at producing an interim subsonic aircraft for the NATO nations. Rolls-Royce and MAN are already collaborating on development of the powerplant for the Südring Mach 3 VTO fighter project. The French and German Defence Ministers have also agreed to cooperate in the development of a similar supersonic VTO combat aircraft.

The West German Defence Ministry has announced a £875,000 order to Rolls-Royce to supply *Tyne* turboprop engines for three *Transall* C.160 prototypes. De Havilland Aircraft Company has received a £500,000 contract to supply propellers. Normalair Limited is supplying three sets of cabin air conditioning and pressurization equipment valued at £40,000.

The new Grumman W2F Hawkeye *radar early-warning aircraft. Each fin has a rudder with trim tab extending over its entire length, similar to the S2F series. Developed as a successor to the WF-2 AEW aircraft now in service with the U.S. Navy,* Hawkeye *is powered by two 4,050 eshp Allison T56-A-8 turboprops and carries a General Electric radar in a dish-shaped "Rotodome". Wing span 80 ft 7 in; length 56 ft 4 in. Maximum take-off weight 49,500 lb.*

De Havilland Aircraft of Canada Ltd., has received a further order valued at $16 million to supply an additional 24 DHC-4 *Caribous* to the U.S. Army. The total U.S. Army order now stands at 51 *Caribous*, and the RCAF has ordered five. Production will extend through 1962 at Downsview.

Aeronautica Macchi and Sprague Engineering Corp. of California have signed a licence production agreement under which Macchi will manufacture the U.S. company's test and maintenance equipment for aircraft and missiles. Macchi is to set up a new production department to handle this work.

Sud-Aviation has appointed Nozaki Sangyo K. Kaisha of Tokyo as General Sales Agent for the company's helicopters in Japan. Nozaki will launch an extensive sale campaign for Sud-Aviation, in competition with four other Japanese companies representing U.S. helicopter manufacturers: Mitsubishi Shoji Kaisha—Sikorsky S-51, S-62; C. Itoh & Co. Ltd.—Vertol 107; Mitsui Bussan Kaisha Ltd.—Bell HU-1A/B; and Nissho K. Kaisha—Kaman H-43B and HU-2K.

Japan Aircraft Maintenance Co. Ltd. has signed an agreement with Boeing International to operate an authorized Boeing maintenance and service centre for 707/720 transports. JAMCO will be certificated by the Japanese Civil Aviation Bureau and the U.S.

The Sikorsky S-61L large commercial transport helicopter commenced flight testing at the end of 1960. The non-amphibious S-61L is powered by two 1,250 h.p. General Electric CT58-110 shaft turbines. Los Angeles Airways has ordered 5, and Chicago Helicopter Airways 4, for service in 1961.

Federal Aviation Agency. This is the second Boeing centre, the first being operated by Lockheed Aircraft Services in New York.

Westfälische Metall Industrie KG, Hoeck & Co., of Lippstadt has signed an agreement with D. Napier and Son Ltd., covering exclusive manufacturing and sales rights throughout West Germany for the Napier Spraymat electrical de-icing system. The initial requirement is for equipping the Lockheed F-104Gs on order for European air forces. Spraymat is also on order for the wings and tailplanes of the Transall C-160 military freighter. The WMI company also has a licence for the manufacture of aircraft equipment developed by Bronzavia SA (the French licensee for Spraymat), and the three companies will be working in close cooperation.

British Government purchase of the Rolls-Royce RB.168 (military version of the RB.163 *Spey*) has now reportedly been approved. This presumably means that a new order for RB.168-powered Blackburn NA.39 strike aircraft has also been placed for the British Navy. This will accelerate Rolls-Royce's development programme on the RB.163, using the NA.39 as a testbed.

Fokker has received an order from Philippine Air Lines for a third F.27 *Friendship*, bringing the total order book for the turboprop passenger transport to 86 aircraft. Pakistan International Airlines put the first of five *Friendships* into service on domestic routes in January.

Turboméca has delivered a batch of *Marboré* turbojet engines to Yugoslavia to equip two twin-jet prototypes, the T.451 MM *Hornet* (two seat) and S.451 MM *Queenbee* (single-seat) primary trainers.

MILITARY AFFAIRS

The European Lockheed F-104 programme now covers a total of 1,075 aircraft. The European production will cover 949 F-104 G *Starfighters*, and West Germany will get a further 126 F and G models direct from the U.S. West German Air Force strength will be 730 F-104s, 604 manufactured in Europe; 30 U.S.-manufactured F-104Fs have already been delivered and a batch of 96 F-104Gs is in production at Lockheed. The Belgian Air Force will have 100 European-manufactured F-104Gs, 25 paid for by U.S. military aid funds. The Netherlands Air Force will have 120, with 25 paid for by the U.S. The Italian Air Force will have 125, with 50 paid for by the U.S. The 100 F-104Gs financed by the U.S. will involve a contract of about $140 million, approximately $1.4 million per aircraft.

Cancellation of the Republic Aviation contract for development of the AN/USD-4 *Swallow* medium-range surveillance drones leaves the U.S. Army with two active drone development programmes. These are the SD-2 short-range propeller-driven drone under development by Rheem Division of Aerojet General Corp, and the SD-5, a long-range jet-propelled drone under development by Fairchild Engine and Airplane Corp. Republic's sub-contractors will continue work on SD-4 components for use in other projects: Texas Instruments—terrain avoidance radar; Chicago Aerial Corp.—KA 30 camera; Aeroflex Corp.—stabilized mounts for sensors; IT&T—command guidance system.

Ellsworth AFB, South Dakota, has been selected by the Air Force as the second *Minuteman* fixed site, and will have three squadrons (150) of the solid-propellant ICBM weapons. Ground survey work has also been started near Pease AFB near Portsmouth, N.H., as a possible site for the next wing. The first *Minuteman* fixed site is at Malmstrom AFB, Montana. Two squadrons of mobile *Minutemen* will be supported at Hill AFB, Utah.

The Brazilian Navy has taken delivery of three Westland *Whirlwind* series 1 helicopters under a £200,000 contract, including spares. The *Whirlwind* will be operated aboard the 18,040-ton Brazilian aircraft carrier *Nael Minas Gerais* (formerly *HMS Vengeance*), recently refitted in the Netherlands.

French designer Yves Gardan has built the YG. 80 4-seat low-wing touring aircraft, pictured above, for rational quantity production. Powerplant is a 150 h.p. Lycoming O-320 engine, and a two-blade metal propeller is employed in the standard version. Cruising speed is 135 kts at a maximum weight of 2,250 lb and 75 percent of normal rating. Take-off distance 1,210 ft. Maximum range at 66 percent of nominal rating 590 n.m. The first prototype began flight testing in 1960, and a second aircraft should be ready to fly in early 1961. Price NF 66,000 standard version, and NF 79,500 de luxe.

Prototype of the Breguet 941 STOL transport which is scheduled to begin flight testing in April this year. A delegation from the French postal services has recently visited Breguet's Vélizy-Villacoublay facility to study the 941's suitability for air mail services.

The first Alizé ASW aircraft on order for the Indian Navy was handed over at Breguet's Villacoublay plant last month. Delivery will be completed at a rate of two *Alizés* per month.

Selection of a twin turboprop light transport for the French Air Force is expected this month. Types under final study are the Breguet 945, Dassault *Communauté* and Nord-Holste *Super Broussard*. The projected production programme covers some 80 aircraft and will require credits totalling NF 180 million ($36 m.).

The Italian Navy has received its first Convair Terrier surface-to-surface weapons, the first NATO country to get the missile. *Terriers* will be installed aboard the guided weapons cruiser *Garibaldi* which has two independent fire control systems.

The U.S. Army has given The Martin Company a $76,921,772 contract to carry forward development of the two-stage *Pershing* surface-to-surface tactical missile to July 31st. The contract covers production of missiles for research and development, ground support equipment and tools, and brings the total Army award to Martin to $138,489,470 for the fiscal year ending June 30th, 1961. Flight tests of the solid-propellant *Pershing* have been highly successful.

Book Reviews

AGARD Aeronautical Multilingual Dictionary. — Published by the NATO Advisory Group for Aeronautical Research and Development (AGARD). Edited by G. H. Frénot and A. H. Holloway. — Pergamon Press, London, 1960 (eight languages; approx. 950 pages; price £7).

Standardized technical expressions and precise definitions are a prerequisite for the exchange and translation of technical and scientific information. Although large numbers of dictionaries exist, there is some hesitation in using them, as discrepancies are all too often found. The endeavours of the AGARD Documentation Committee to create a reliable source of information are therefore highly welcome.

The recently published AGARD eight-language aeronautical dictionary contains 1,574 words and expressions. It is divided into fifteen sections, in which the English expressions with their definitions are arranged alphabetically and numbered; they are followed by the French, German, Spanish, Italian, Dutch, Turkish and Russian translations. In an index at the end of the volume the words are again listed alphabetically in each language, together with their numbers, so that the definitions and translations can be easily found.

The dictionary, which is based on the *Glossary of Aeronautical Terms* (British Standard 185), contains only basic words and expressions in its individual sections. Present-day aviation is divided into so many specialized fields, each of which possesses its own terminology, that the expressions used in these fields cannot be listed in a single volume. If enlarged, however, the dictionary could form the basis for a comprehensive standard work (even now, there are plans to extend it by a further 1,287 words). For it is precisely the specialized terminology which presents the most difficulties for translation purposes.

Eb.

Starten und Fliegen. Das Buch der Luftfahrt und Raumfahrt, Band V. Edited by Otto Fuchs, Wolfgang von Gronau, Eugen Sänger; Editor of the series: Hans-Joachim Luz. — Deutsche Verlagsanstalt, Stuttgart, 1960 (German; 388 pages, 300 illustrations; price DM 16.80 cloth-bound).

If the technical qualifications of the editors were not already well known to readers, they might be surprised that the "Starten und Fliegen" year-book has won such a prominent place for itself in German and international aviation literature in so short a time. A careful choice of themes and an intelligent arrangement of the subject matter ensure that justice is done to every main sector of the vast field of modern aviation and astronautics. As for the authors, all the articles are by leading specialists in the subject concerned. The illustrations are instructive, the presentation impeccable. It is regrettable that the space allowed for book reviews does not leave room for textual quotations. The most that can be done is to mention the names of a few authors and their papers: *Hall L. Hibbard*, Vice President (Engineering) of Lockheed Aircraft Corporation, "Supersonic Flight in Anticipation and in Retrospect"; *Professor Siegfried L. Gerathewohl*, former Director of the U.S. Army Ballistic Missile Agency's Bioastronautics Research Office, "Little Monkeys and Big Rockets"; *Krafft A. Ehricke*, Programme Manager for Project *Centaur*, Convair (Astronautics) Division, General Dynamics Corp., "Astronautic Goals 1965-1985"; *Professor Armin Dadieu*, Forschungsinstitut für Physik der Strahlantriebe, "The Significance of Propellants in Rocket Development"; *Peter Brett*, Chief Project Engineer, de Havilland Propellers Ltd., "Propellers for Turboprop Aircraft"; *Professor Wolfgang Liebe*, Berlin Technical University, "Aerodynamic Tricks to Increase Flight Safety"; *Raoul Hafner*, Technical Director, Westland Aircraft Ltd., "The Tandem Helicopter." *Hans Zacher*, of the Flugwissenschaftliche Forschungsanstalt, Munich. has provided the illustrated inserts on famous sailplanes. The introduction, "From Year to Year," which in volume IV was written by E.E. Heiman, the late Editor-in-Chief of *Interavia*, this time came from the pen of *Dr. Theodor Benecke*. The editors look forward to reviewing volume VI of "Starten und Fliegen."

He.

Saint-Exupéry. Sein Leben. — By Marcel Migeo. — Rainer Wunderlich Verlag Hermann Leins, Tübingen, 1960 (German, translated from the French by Gerlinde Quenzer; 392 pages, 3 illustrations; cloth-bound; price DM 19.80).

Who was Saint-Ex? Although we know him from his books, in which he recounts so vividly his flights across deserts and seas, they provide only part of the answer. Migeo gives us a more comprehensive one. He follows the writer on his restless, fateful career, from his childhood in Provence to his last flight from Corsica in a *Lightning*, on July 31st, 1944. This concise work gives us an even closer knowledge of Saint-Exupéry the man, the pilot and the creator of the delightful "Petit Prince." than we have from his works.

De.

Books Received

Die Höhenwinde über dem tropischen und südlichen atlantischen Ozean. — By Erich Kuhlbrodt. — Wissenschaftliche Ergebnisse der Deutschen Atlantischen Expedition auf dem Forschungsschiff "Meteor" 1925-1927, Band XVI, erster Teil, dritte Lieferung, Abschnitt C, Kapitel I-III (Besprechung der Ergebnisse: Die Luftströmungen über dem tropischen Atlantik). — Edited by A. Defant for the Deutsche Forschungsgemeinschaft. — Walter de Gruyter & Co., Berlin, 1960 (German; 135 pages with 53 illustrations; price DM 54.—).

MAGIRUS-DEUTZ AIRCRAFT TOWING TRACTORS

For towing jet airliners of gross weights up to 160 tons, Magirus-Deutz has developed the ORION 250, an aircraft towing tractor with the powerful 250 h.p. Deutz Diesel engine. Power transmission is through a progressive hydraulic torque converter, which guarantees smooth, shock-free starting. If required, the ORION 250 can be equipped with a three-phase electric powerplant which supplies the aircraft with current before starting.
For towing and moving aircraft of gross weights up to 65 tons, and for other airport transportation tasks, the ORION 70 has proved the ideal vehicle.

KLÖCKNER-HUMBOLDT-DEUTZ AG · WERK ULM · WESTERN GERMANY

MAGIRUS DEUTZ

alouette II

WORLD ALTITUDE RECORD FOR HELICOPTERS OF ALL CATEGORIES (11,000 metres on June 13th, 1958)

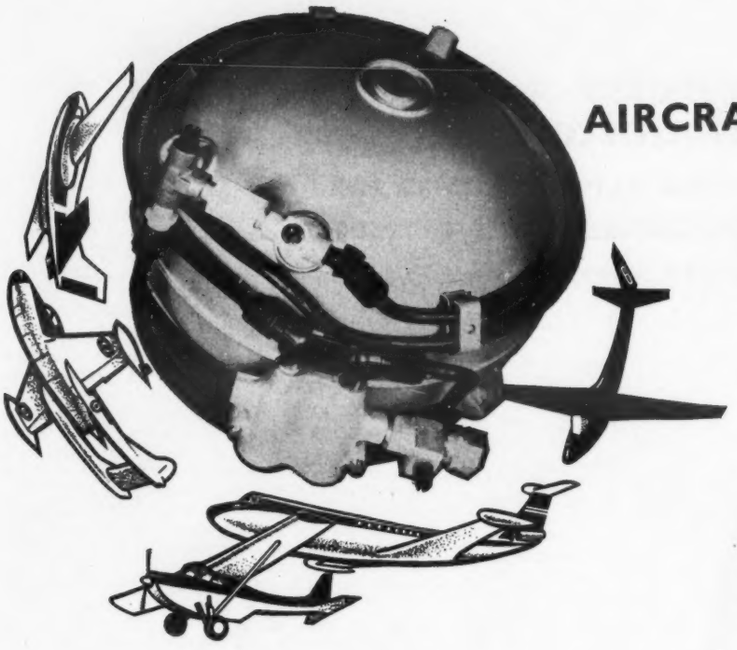
the best helicopters for high-altitude operations

alouette III

LANDINGS ON MONT BLANC (4810 metres) WITH 6 PEOPLE ON BOARD, ON JUNE 12th, 13th AND 22nd, 1960

SUD AVIATION

37 - BOULEVARD DE MONTMORENCY - PARIS (16e) - TÉL. : BAG. 84-00



AIRCRAFT OXYGEN EQUIPMENT

for
High altitude sail planes
Light aircraft
Executive Transport aircraft
Large and medium airliners
Military aircraft

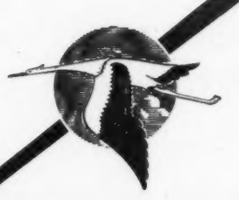
Oxygen systems are technically and operationally complementary to the pressurisation and air conditioning systems of modern aircraft.

Normalair Ltd. of Yeovil, England, the largest manufacturers of pressurisation and air conditioning equipment in Europe can provide oxygen equipment for crew and passenger use, for aircraft evacuation at altitude, as fixed or removable installations — or as "drop down" sets for civil passengers. Normalair also design and make a wide range of converters to enable liquid oxygen to be used as the supply medium with the utmost economy and safety.

NORMALAIR YEOVIL ENGLAND

Normalair (Canada) Ltd. Toronto · Normalair (Australia) Pty Ltd. Melbourne

JET ENGINES
UNDERCARRIAGES
MACHINE TOOLS
NUCLEAR ENGINEERING
ENGINEERING STUDIES
DIESEL ENGINES



HISPANO SUIZA

BOIS-COLOMBES – SEINE – FRANCE

DECCA for EXECUTIVE AIRCRAFT

A growing proportion of industrial organisations, using aircraft for rapid transport, fit Decca as their primary navigation system. They realise that their investment of large sums of money in aircraft must be protected by installing only the finest navigational equipment. Their choice of the Decca Navigator is based on the unique advantages that only Decca can offer.

Accuracy
No navigational errors, no plotting, no calculations, you can see your exact position at a glance. Accurate track keeping and ETAs ensure expeditious handling by ATC.

Economy
2-pilot operation is superfluous thus cutting cost-per-hour in running the aircraft and saving the weight of the second pilot, instrumentation, etc.

Flexibility
All-altitude coverage in Western Europe permits direct, accurate flying from take-off to touchdown—on or off airways. Any track, straight or complex, can be flown.

Pictorial Presentation
The Flight Log gives a continuous, automatic display of the aircraft's position in relation to the ground. Ground speeds are easily computed, changes of wind are shown immediately. Exact flying under all conditions is ensured.

24-Hour Charting Service
Flight Log Charts for a particular flight, ready to be fed into the flight log, are available at short notice. Charts can also be prepared by the pilot.

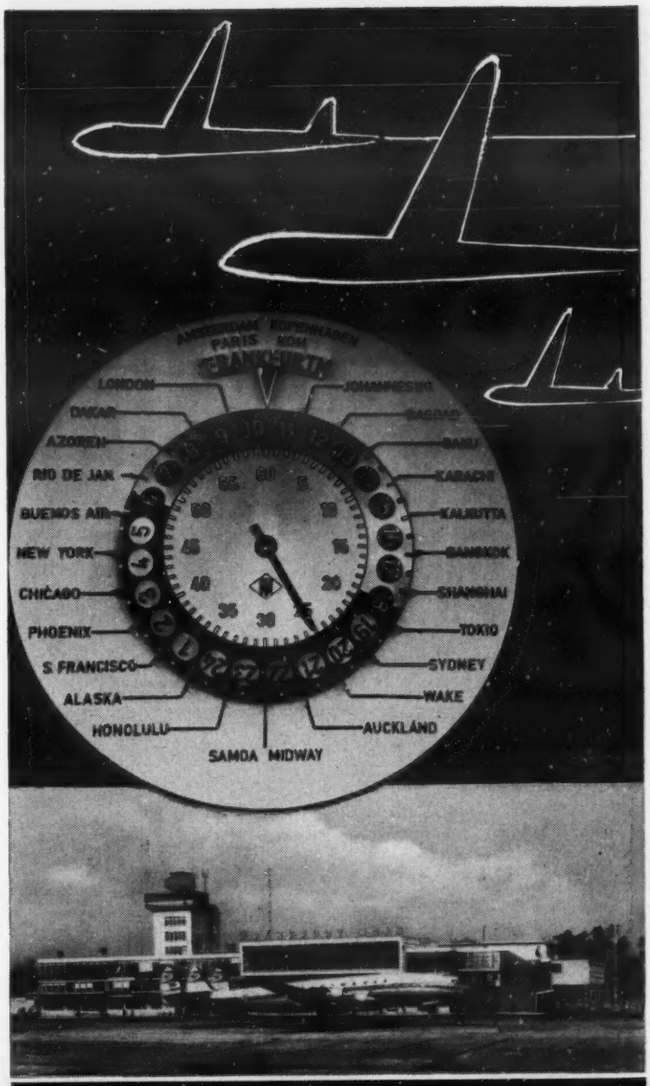
Approach Aid
In certain parts of the coverage accuracy permits safe approaches on Decca—Flight Log Charts show runway extensions and distance from touch down. Similar facilities can also be obtained from Decometer readings.

Decca equipment is light and compact. Where flexibility, reliability, accuracy and economy are required the specification is

THE DECCA NAVIGATOR

the world's most accurate navigation system

THE DECCA NAVIGATOR COMPANY LTD LONDON



We are the suppliers

of the master clock system for Germany's largest airport, **RHINE-MAIN**, which is equipped with a large number of handsome repeater clocks, including a world time clock and the comprehensive fire warning and alarm system.

TELEFONBAU + NORMALZEIT FRANKFURT/M

NOW!

COMET 4C

First and Tourist Class

M·E·A

FOR INFORMATION AND BOOKINGS:
CONSULT YOUR IATA TRAVEL AGENT OR OFFICES OF MIDDLE EAST AIRLINES EVERYWHERE.

MIDDLE EAST AIRLINES

FLIGHT EQUIPMENT
AUTOPILOTS
MASTER REFERENCE GYROS
HORIZON GYROS - "SYNTHETIZERS" (FLIGHT DIRECTOR)
DIRECTIONAL - RATE GYROS
STANDBY AND REMOTE COMPASSES
SERVOMECHANISMS
S.F.E.N.A.
SOCIÉTÉ FRANÇAISE D'ÉQUIPEMENTS POUR LA NAVIGATION AÉRIENNE
AVIONICS
AIRCRAFT AND MISSILE TRAJECTORY RECORDING, GUIDANCE AND AUTOGUIDANCE SYSTEMS
TELECONTROL - TELEMETERING
ACOUSTIC MISS-DISTANCE MEASUREMENT
SIÈGE SOCIAL : 25 à 29, RUE DU PONT NEUILLY SUR SEINE MAILLOT 49 35

Clichés
Schwitter S A
Bâle Zurich
Lausanne

Clichés pour impression en une ou plusieurs couleurs
Galvanos Albert Fischer
Stéréos - Flans
Clichés pour gaufrage et reliure
Clichés en bakélite
Clichés en caoutchouc
Retouches américaines
Photos en couleurs pour l'art et l'industrie
Agrandissements photographiques

ZENITH CARBURATEURS

MANUFACTURES FUEL FILLING EQUIPMENT AND CIRCULATION SYSTEMS FOR ALL AIRCRAFT, AS WELL AS AIRFIELD REFUELLING SYSTEMS

*

EQUIPS THE FOLLOWING AIRCRAFT:

CARAVELLE - ÉTENDARD - MAGISTER - MIRAGE
NORATLAS - SUPER MYSTÈRE - VAUTOUR etc...

LICENCES FOR BENDIX - HOBSON - FLIGHT REFUELLING PLESSEY - SAUNDERS VALVE

17, Rue Louise Michel - Levallois-Perret - PEReire 17-02

A sound tradition

1854

Foundation as an issuing bank in the former free city of Frankfurt am Main

1901

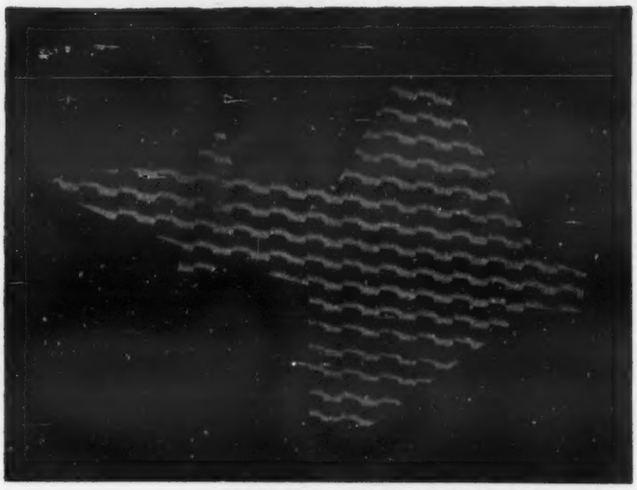
Conversion to a trustee bank

1946

Charter extended to include the functions of a centralized credit bank with connections throughout Federal Germany

Over a century of confidence from all sectors of economy has resulted in this many-sided development

FRANKFURTER BANK



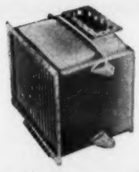
Pub. AL

AIRCRAFT HEAT EXCHANGERS

LIGHT, COMPACT

ARE NOW AVAILABLE

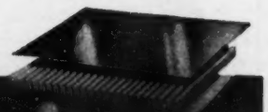
IN THE ALUMINIUM HEAT EXCHANGER



- **Oil coolers**
- **Heat exchangers for electronic equipment cooling circuits.**
- **Engine supercharger intercoolers and cabin air coolers...**

These are some of the applications of CEMAT heat exchangers.

Constructed of plates interleaved with corrugated metal, the CEMAT heat exchanger can be mass produced by furnace brazing.

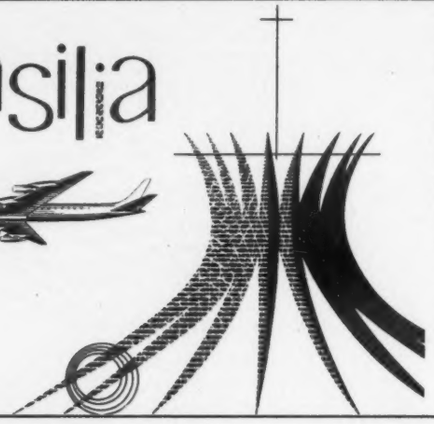


CEMAT

COMPAGNIE EUROPÉENNE DES MATÉRIELS THERMIQUES

75, QUAI D'ORSAY, PARIS 7e - TEL. INV. 44-30

brasilia



Birth of a capital

PANAIR DO BRASIL links BRASILIA with the great cities of the Old World : LISBON, MADRID, PARIS, LONDON, ROME, FRANKFURT, DÜSSELDORF, ZURICH, BEIRUT.

PANAIR, which has for many years held the record for South Atlantic crossings, will very soon be placing the *DOUGLAS DC-8*, most recent of the long-range jets, in service on its trans-Atlantic routes.

PANAIR DO BRASIL

South America in the Jet Age

CONTINENTALE

narco

ADF-29

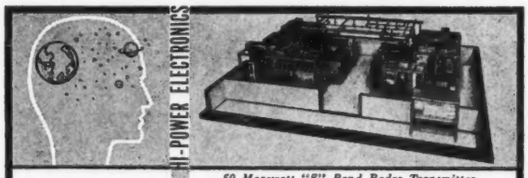
- Weighs only 8 pounds complete !
- All-Transistorized
- Draws only .54 Ampere
- Completely self-contained, mounts on instrument panel

New NARCOMATIC SENSOR has no moving parts, derives direction information from strongest station signal, not the NULL.

narco DISTRIBUTED OVERSEAS BY

Van Dusen **AIRCRAFT SUPPLIES,**

Telerboro, N. J., U.S.A. Cable VANDUSAIR



HI-POWER ELECTRONICS

50 Megawatt "S" Band Radar Transmitter

The result of complex challenges

FXR's advanced techniques and facilities have produced the 50 Megawatt "S" Band Radar Transmitter for Cornell Aeronautical Laboratories. This transmitter, more than twice as powerful as the formerly largest unit of its class, will be used in the electronic exploration of the atmosphere and the ionosphere.

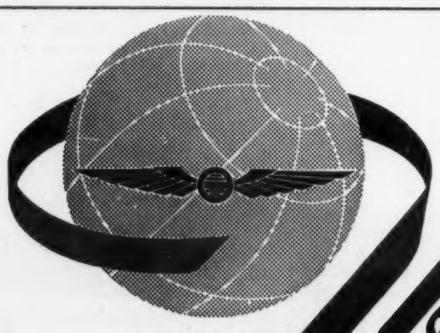
FXR has an extensive achievement record in solving demanding problems. Put this creative ability to work to help solve your High Power Electronics problem.

For detailed information concerning your particular application, contact your FXR applications engineer. He is only a phone call away.

FXR, Inc.

Design • Development • Manufacture

25-26 50th STREET • RA. 1-9000
WOODSIDE 77, N. Y. • TWX: NY 43745

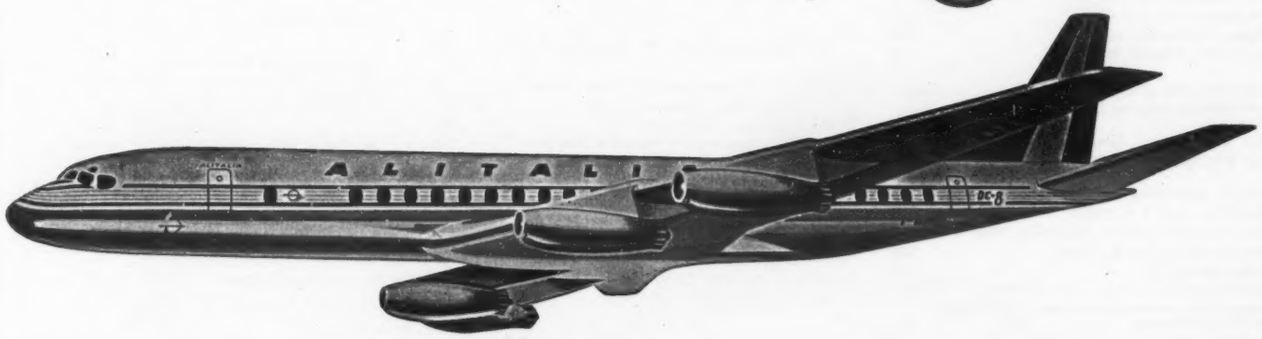


SERVICES LINKING
4 CONTINENTS

Iberia

LÍNEAS AÉREAS DE ESPAÑA

Super DC-8 jet



THE MOST MODERN AND COMFORTABLE JET PLANE

ALITALIA

Helicopter

AGUSTA - BELL 102

certificated by the R.A.I. to C.A.R. standards

Characteristics

Engine rating	600 h.p.
Overall weight	6,008 lb
Payload	2,017 lb
Maximum speed	110 m.p.h.
Cruising speed at 1,950 feet above sea level	99 m.p.h.
Service ceiling in forward flight (max. weight)	12,800 ft
Hovering ceiling within the ground effect	8,100 ft
Endurance with normal tanks	3 hours 20 min

The most recent product of

COSTRUZIONI AERONAUTICHE

GIOVANNI AGUSTA

CAMPO DI CASCINA COSTA - GALLARATE (ITALY)

List of Advertisers in "Interavia" February 1961

Air France, Paris 150
L'Air Liquide, Paris 247
Alitalia, Rome 249
Alvis Limited, Coventry 137
Ampex, Redwood City, Calif. 138-139
Atlas Copco A.B., Stockholm 230
Aviradio, Issy-les-Moulineaux 213
Avions Louis Breguet, Paris 160

Bendix International, New York 210-211
Bristol Siddeley Engines Ltd., (Ball Screws), Coventry 162
British Aircraft Corp., London 195-1958
British Petroleum Co. Ltd., London 179

Champion Spark Plug Co., Toledo, Ohio 152
Clichés Schwitter, S.A., Basle 246
Collins Engineering Corp., Culver City, Calif. . . 250
Contraves Italiana S.p.A., Rome 208
Convair, San Diego 252
Cossor Radar & Electronics Ltd., Harlow 156
Costruzioni Aeronautiche Giovanni Agusta, Cascina Costa (Gallarate) 249
Cubic Corp., San Diego, Calif. 154

Daimler-Benz A.G., Stuttgart 147
Decca Navigator Co. Ltd., London 245
Decca Radar Ltd., London 223
Deutsche Lufthansa GmbH., Cologne 226

Edo Corporation, College Point, N.Y. 128
Electric Autolite Co., New York 224

Ferranti Ltd., Hollinwood 227
Fiat S.p.A., Turin 141
Firestone Tire & Rubber Co., Akron 157
Frankfurter Bank A.G., Frankfurt 247
FXR Inc., New York 248

Générale Aéronautique Marcel Dassault, Paris. . 143

The de Havilland Aircraft Ltd., Hatfield . . . 134
Hawker Siddeley Aviation, London 130, 155
Hispano-Suiza, Bois Colombes 244
Hollandse Signaalapparaten, N.V. Hengelo . . . 142
Hughes Aircraft Co., Culver City, Calif. . . . 148-149

Iberia, Madrid 248

Keegan Aviation Ltd., Panshanger Aerodrome, Herts. 250
Kléber-Colombes, Paris 144
Klöckner-Humbold-Deutz, Ulm 242

Laboratory for Electronics, Boston, Mass. 225
Lear Inc., Santa Monica 182

McDonnell Aircraft Corp., St.Louis, Mo. 126
Marconi's Wireless Telegraph Co., Chelmsford 151, 153
MATRA, Boulogne 250
Middle East Air Lines, Beirut 246
Minneapolis-Honeywell Regulator Co., Minneapolis 132

Narco, Teterboro, N.Y. 248
Nord-Aviation, Châtillon s/ Bagneux 251
Normalair Ltd., Yeovil 244
Northrop Corporation, Hawthorne 180-181

Omnipol, Prague 212

Panair do Brasil, Rio de Janeiro 248
Piper Aircraft Corporation, Lock Haven 158
The Plessey Co. Ltd., Ilford 207, 214

Redifon Limited, London 133

Servo Corp. of America, Hicksville, L.I., N.Y. . . 140
SFENA, Neuilly 246
Smiths Aviation Div., Wembley 159
Standard Telephones & Cables Ltd., London . . 161
Ad. Strüver GmbH., Hamburg 131
Sud-Aviation, Paris 243
Svenska Aeroplan A.B., Linköping 209

Technocommerz GmbH, Berlin 228
Telefonbau & Normalzeit GmbH., Frankfurt . . . 245
Telefunken GmbH., Ulm 129
Thomson-Houston, Paris 229

UAT, Paris 127

Carburateurs Zénith, Levallois-Perret 247

Keegan Aviation LTD.

What we advertise — we own

D.C.4. Choice of two. 73 seater "E" model. 68 seater "B" model. Both just completed major overhaul and tank re-sealing.

D.H. Doves. Choice of two. Both have spar mods just fitted, new interior and major overhauls completed.

AERO COMMANDER. Last 520 model built. 2 VOR's. ILS. ADF. A superb executive aircraft cruising at 200 mph. over 1100 miles.

PIPER SUPER CUSTOM APACHE. Extensively equipped with electronics and radio. A beautiful specimen.

BRISTOL FREIGHTER MK21. Nose opening doors. 55 passenger seats. Just completed check IV.

KEEGAN AVIATION LTD.
Panshanger Aerodrome Hertford, England
Telephone: Essendon 491/2 Cables: Planesales, Hertford - Telex: 1943

World's Largest Stock of Parts for F86 - T33 - P80 - C121 - T28 - F94 - T6 - C46 - DC3 - 4 - 6 All Models

New unused surplus parts every class. Direct out of US Air Force Base. Make best offer with enquiries. No reasonable offer refused. Also, industry's largest stock of AN Hardware. Send for catalogue and free wall charts. Foreign Representatives needed.

COLLINS AIRCRAFT CORPORATION
9050 Washington Boulevard, Culver City, California, Cable "JOCOCO"

ENGINS MATRA
S. A. Capital 10,000,000 NF

MISSILES
AERONAUTICAL ARMAMENT

27, Quai de Boulogne BOULOGNE-sur-SEINE
Telephone: MOLitor 60-10

Papier couché Massey: Papeterie de Cham S.A., Cham
Cover, four colour printing and photogravure: Fabag Druck Zurich • Letterpress printing: Imprimerie de la Tribune de Genève
Printed in Switzerland

MAX HOLSTE • NORD-AVIATION

"Super Broussard"

20—23 PASSENGERS
FREIGHT

SWIFT
COMFORTABLE
ROBUST

ECONOMICAL AND MODERN TRANSPORT

THE ONLY 2x1,000 HP TURBOPROP TO BE PRODUCED IN QUANTITY

NORD • AVIATION 2 à 18, RUE BÉRANGER • CHATILLON s/s BAGNEUX • SEINE • TEL. ALESIA 57-40

CONVAIR'S 880...
the
world's
fastest jet
passenger
plane is

Now in service...

While others are still in the air, you're there on the Convair 880—the fastest passenger jet in the world. Climbing fastest, cruising fastest, the 880 cuts your travel time *and* travel fatigue. Even at 615 miles per hour you feel no vibration—hear only the murmur of the powerful General Electric jet engines and the whisper of the wind as it passes your windows. The Convair 880 is *now in service* with Delta and Northeast. Among other leading airlines soon to offer Convair 880 or 990 service will be TWA, AMERICAN, SWISSAIR, S.A.S., REAL AEROVIAS (Brazil), C.A.T. (Formosa), AVENSA (Venezuela), JAL (Japan), ALASKA AIRLINES.

CONVAIR
DIVISION OF GENERAL DYNAMICS